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FIELD EXPERIMENTS ON SOILS AND CROPS

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BULLETIN NO. 272

Field Experiments on Soils and Crops

By GEO. ROBERTS, E. J. KINNEY and J. F. FREEMAN

INTRODUCTION

This bulletin is a progress report upon various soil and crop experiments being conducted by the Department of Agronomy on the Experiment Station farm at Lexington and on the soil experiment fields located in various parts of the State.

Many of these experiments were reported upon in Bulletin No. 228, which brought the results up to and including the year 1919. This report includes results through 1925.

The reader is referred to Bulletins 199 and 228 for some details of the plans of the experiments that are not included in this report.

The values of crop increases and cost of fertilizers and limestone have not been computed for the reason that prices of crops and fertilizers vary greatly, not only from year to year, but in the different localities of the State, especially in the case of limestone.

Those interested may calculate the value of the increase and the cost of the treatment producing the increase upon the basis of the prices prevailing in their localities. A fair average basis of calculation is suggested:

Corn	$0.80 per bushel.
Wheat	1.25 per bushel.
Clover and soybean hay	.75 per 100 lbs. field cured weight.
Limestone	2.50 per ton.
Acid phosphate	1.20 per 100 lbs.
Rock phosphate	.60 per 100 lbs.
Potash salts	3.00 per 100 lbs.
Nitrate of soda	3.75 per 100 lbs.

In a four-year rotation the following amounts of limestone and fertilizers may be charged against the four crops, according to the treatment:

Limestone	2 tons
Acid phosphate	800 lbs.
Rock phosphate	1,600 lbs.
Potash salts	200 lbs.
Nitrate of soda as indicated in the experiments.	

In a three-year rotation three-fourths of the phosphate and potash indicated above may be charged.

EXPERIMENTS ON THE STATION FARM AT LEXINGTON

The Lexington Soil Experiment Field

The Four-Year Rotation. This field represents the soils of the Trenton geological formation. Work was begun on it in 1911. The principal rotation is corn, soybeans, wheat and clover.

Organic matter and nitrogen are provided as follows: Where residues are specified (designated by "R" in the tables) the cornstalks are left on the ground, a cover crop, usually rye, is sown in the corn and turned under the next spring, the straw from the soybeans and wheat is spread upon the corresponding plots of the clover sod that is to be turned for corn, and the second crop of clover is left on the ground. The return of residues was not begun until 1916. Plots 5 and 10 have not received the cornstalks, soybean straw and wheat straw, but the second crop of clover has been left on the ground.

Limestone and fertilizers have been used at the following rates for the rotation:

Limestone was used at the rate of 4 tons per acre from 1911 to 1915; 2 tons per acre from 1916 to 1918; 1 ton per acre from 1919 to 1922; since 1922 no limestone has been used.

Acid phosphate was used at the rate of 800 pounds per acre from 1911 to 1922 when it was reduced to 400 pounds per acre.

Sulfate or muriate of potash was used at the rate of 500 pounds per acre from 1911 to 1915; 400 pounds per acre from 1916 to 1922; 200 pounds per acre since 1922.

Limestone and fertilizers were applied after the clover sod was broken for corn and were worked into the soil in the preparation of the seed bed. The applications were for the four-year rotation period.

Table 1 gives the yields of crops on this field from 1911 to 1925. The first crop of corn was in 1911; of soybeans in 1912; of wheat in 1913; and of clover in 1914. No attempt was made to get any of the other crops before their places following the first crop of corn.

TABLE 1.—Average Crop Yields Per Acre in the Four-Year Rotation, Lexington Soil Experiment Field.

Serial Plot No.	Treatment	Corn Bus. Ave. 15 Crops, 1911-1925	Soybeans Bus. Ave. 14 Crops 1912-25	Wheat Bus. Ave. 12 Crops. 1913-1925	Clover, Lbs. Ave. 8 Crops, 1914-1925	Soybean Hay Lbs. Ave. 2 Crops, 1916-17
1	RP	43.2	18.5	24.6	4590	4440
2	RK	43.1	19.0	25.4	4712	4290
3	R	47.4	18.4	25.1	4658	4350
4	RPK	45.9	18.7	25.1	4611	4284
5	PK	49.1	18.1	24.8	4631	3900
6	RLP	49.3	18.1	25.5	4620	3570
7	RLK	53.9	18.7	25.6	4559	3750
8	RL	54.6	17.8	25.2	4515	3492
9	RLPK	54.3	19.7	27.0	4707	3846
10	O	55.0	17.8	24.0	4125	3402
11	RP	52.1	17.8	24.7	4269	3390
12	RK	52.1	17.9	24.9	4678	3678
13	R	54.0	17.5	25.0	4275	3852
14	RPK	52.8	18.1	24.8	4624	3714
15	RLPK	51.5	19.4	26.9	4560	3978
	Averages of Duplicate Treatments					
1, 11	RP	47.7	18.2	24.7	4430	3915
2, 12	RK	47.6	18.5	25.2	4695	3984
3, 13	R	50.7	18.0	25.1	4467	4101
4, 14	RPK	49.4	18.4	25.0	4618	3999
5	PK	49.1	18.1	24.8	4631	3900
6	RLP	49.3	18.1	25.5	4620	3570
7	RLK	53.9	18.7	25.6	4559	3750
8	RL	54.6	17.8	25.2	4515	3492
9, 15	RLPK	52.9	19.6	27.0	4634	3912
10	O	55.0	17.8	24.0	4125	3402

R = crop residues; P = acid phosphate; K = potash salts; L = limestone.

There was one wheat failure in the period, the crop of 1924. On account of dry weather in the fall of 1923 it did not germinate until November and was winter killed.

There were three clover failures in the period of 1914-24. These occurred in 1916, 1917 and 1921. The failure in the spring of 1916 was due to drouth. The ground was prepared and reseeded in the summer, when a good stand was obtained, but grasshoppers destroyed it. The crop due in 1917 was winter killed. The crop due in 1921 came through the mild winter in rather poor condition, due apparently to disease attacks and the hard freezes in March and April killed it.

For the crop of 1924 alfalfa was substituted for clover in order to test the effects of the various treatments on alfalfa and to test its behavior when sown in spring grain.

Clover failures are not included in the averages. It is a noteworthy fact that the failures were the same on all the plots.

The Three-Year Rotation. On this same field is a three-year rotation of corn, wheat and clover. One set of plots is limed and another set unlimed. The corn stalks are left on the ground, the wheat straw is returned to the sod to be broken for corn and the second crop of clover is left on the ground.

The average yields of crops in this rotation are given in Table 2.

TABLE 2.—Average Crop Yields Per Acre in the Three-Year Rotation, Lexington Soil Experiment Field.

Serial Plot No.	Treatment	Corn Bus. Ave. 15 Crops 1911-1925	Wheat Bus. Ave. 12 Crops 1913-1925	Clover Lbs. Ave. 8 Crops 1914-1925	Soybean Hay Lbs. Ave. 2 Crops 1916-17
16	R	55.0	20.2	4363	4575
17	RL	54.9	21.2	4655	3870

The significant thing about these experiments is that no treatment has materially increased the yields. However, the conclusion cannot be drawn that no treatment beyond a rotation is necessary to maintain the productiveness of bluegrass soils.

A history of this field will be instructive in this connection. The soil is typical of the better soils of the Trenton limestone area which includes about 1200 square miles with Lexington as its center.

The distinguishing characteristic of these soils is their high content of phosphorus and calcium. The averages of a large number of analyses show about 9,400 pounds of phosphorus, 3,800 pounds of nitrogen, 26,000 pounds of potassium and 12,000 pounds of easily soluble calcium in 2,000,000 pounds of soil, which is the weight of an acre to the depth of about seven inches.

The Lexington Soil Experiment Field shows about the same averages except for nitrogen. When these experiments were begun in 1911 this soil contained about 4,500 pounds of nitrogen in 2,000,000 pounds of soil. This field was broken out of a bluegrass sod in 1900. How long it has been in bluegrass is not known, but it is known that it was for many years. No manure was returned to this soil between this date and the beginning of the experiments, nor were any leguminous crops turned under so far as can be learned.

The most important lesson from these experiments is that if soils of this character are kept in good condition through the use of crop rotations with legumes in them and by the return of crop residues and manure it will not be necessary to use commercial fertilizers for the ordinary farm crops, including the common clovers, and the use of lime will not need to be frequent or large.

However, if these soils are allowed to become depleted of their organic matter (humus) it is generally necessary to add lime in order to get a satisfactory growth of clover. This was illustrated on this same field where corn was grown continuously on two plots from 1911 to 1922. On one plot the corn stalks were left on the ground and a winter cover crop of rye was used. On the other plot cowpeas or soybeans were planted at the last cultivation and disked in when the rye was sown. The average yield of corn for twelve years on the first plot was 29.4 bushels per acre while on the other plot with the legume catch crop it

was 32.0 bushels per acre. The yield of corn in rotation (see table 1, plot 10) was 55 bushels. In 1923 the legume plot of continuous corn was limed while the other was left unlimed. The yield for that year was 30.2 bushels per acre on the unlimed plot and on the limed plot 48.0 bushels. The largest difference between the two plots any year previous to liming was 9.6 bushels per acre. The plots were changed from continuous cropping with corn to a rotation of corn, wheat, and clover. Wheat was a failure in 1924 for reasons stated above. The yield of mixed red and sweet clover on the limed plot in 1925 was 5,340 pounds per acre, an increase of 840 pounds over the unlimed plot. While a good yield of clover was produced on the unlimed plot, the soil had been reduced to a condition in which it responded to liming. The same tendency appeared in the clover plots in the three and four-year rotations in 1925; while in 1926 clover failed on many of the unlimed plots.

Many farmers in the Bluegrass Region have found lime highly profitable on worn soils. After liming once it should not be necessary again soon if attention is given to the growing of legumes and their proper use. The failure of clover, except in drouth years, is generally an indication that the soil needs liming.

It is a common experience that wheat does not yield well in Kentucky following corn. The yields of wheat in the four-year rotation following soybeans (plots 8 and 13) average 4.8 bushels per acre higher than on the same treatments in the three-year rotation. This difference is without doubt due largely to the influence of the preceding crop aside from any difference in plant food added or removed in the two rotations.

As previously stated, alfalfa was substituted for clover in both the four-year and the three-year rotations in the sowing of 1923. From spring seeding a good stand was obtained but it all died except on limed plots. Plots treated with limestone and potash showed a marked superiority over those treated with limestone only. After harvesting the wheat the entire series of 17 plots was broken and reseeded to a mixture of red clover and alfalfa August 11. A good stand was obtained on all plots which persisted into the winter. Again the alfalfa was decidedly

better on limed plots and better with lime and potash than where lime was used without potash. The yields obtained in the two cuttings in 1924 are of interest.

TABLE 3.—Yields from Combined Seedings of Clover and Alfalfa in the Four-Year and Three-Year Rotations.* Lexington Soil Experiment Field. Pounds Per Acre.

Serial Plot No.	Treatment	1st Cutting	2nd Cutting	Total
1	RP	**4320	‡4032	8352
2	RK	**4980	‡4296	9276
3	R	**4344	‡3600	7944
4	RPK	**4800	‡3660	8460
5	PK	**4920	‡3540	8460
6	RLP	†3300	†1740	5040
7	RLK	†3780	†2400	6180
8	RL	†4020	†1740	5760
9	RLPK	†4644	†2520	7164
10	O	**3480	‡2244	5724
11	RP	**4380	‡2880	7260
12	RK	**5184	‡3420	8604
13	R	**4284	‡3180	7464
14	RPK	†4440	‡3204	7644
15	RLPK	†4344	†2760	7104
16	R	**5325	‡2550	7875
17	RL	†5280	†1980	7260

*Plots 1 to 15 are in the four-year rotation and plots 16 and 17 are in the three-year rotation.
†Yields marked (†) nearly all alfalfa.
‡Yields marked (‡) nearly all crabgrass.
**Yields marked (**) nearly all clover.

Two significant facts in these alfalfa yields are the importance of lime and the effect of potash. Neither has materially affected the yields of the other crops grown in the rotation since the work was begun. Phosphate fertilization has also somewhat affected the growth of alfalfa. The best yields of alfalfa uncontaminated with clover and crabgrass were obtained on plots 9 and 15 where limestone and acid phosphate and potash were used.

It has been well known that liming was necessary for alfalfa on nearly all central Kentucky soils. These are the first results showing any significant effects of potash on alfalfa. While it is not safe to base conclusions upon a single year's results, they are suggestive. For the central Bluegrass Region it is recommended that farmers sowing alfalfa apply muriate of potash or

sulfate of potash at the rate of 100 pounds per acre on a part of the field and 400 pounds of acid phosphate and 100 pounds of potash per acre on another part, leaving a strip without either treatment, lime of course being used on all the ground.

An experiment was conducted on the Station farm for three years through 1913 to 1915 in which one piece of alfalfa was treated with 2 tons of limestone per acre and the other with 2 tons of limestone and 300 pounds of sulfate of potash per acre. The yield for nine cuttings in three years was 8.4 tons without potash and 8.64 tons with potash. Two out of the three years were severe drouth years.

It is quite possible that long continued cropping to alfalfa without the use of potash or the return of manure may make such a heavy draft upon the potash of the soil that when an attempt to reestablish a stand is made it fails for lack of sufficient available potash. Alfalfa uses potash at the rate of about 25 pounds per ton of hay. The potash supply may be kept up by the return of manure at the rate of a ton for each ton of hay removed or by the use of commercial potash fertilizers.

THE RENEWED EXPERIMENTS

The reader is referred to Bulletin No. 228 for a detailed description of these experiments. From 1888 to about 1898 corn was grown continuously on the same land, and treated with various fertilizers. The soil was rather badly worn when the experiments were begun. Where no fertilizers were used the yield of corn averaged about 30 bushels per acre. Wherever a potash salt was used, whether alone or with nitrogen and phosphorus, the yield was practically doubled. The other fertilizing ingredients had little or no effect.

These experiments were on the old part of the Station farm which is a slightly different type of soil from that on which the experiments described above are located. After the experiments were discontinued the land was kept in bluegrass until the experiments were renewed in 1914. The land had poor natural drainage and was partially tile-drained in 1891. The renewed experiments were located on two sets of plots that had been fertilized in the period of 1888 to 1898 in exactly the same way as the

continuous corn experiments. On one set of plots corn has been grown continuously since 1915, while on the other set a rotation of corn and soybeans has been used with cornstalks and soybean straw returned and rye has been used as a cover crop each year.

Fertilizers have been used at the following rates on each crop in the two experiments, these rates being the same as in the old experiments.

Acid phosphate .....140 pounds per acre
Nitrate of soda.....160 pounds per acre
"Muriate" of potash .....160 pounds per acre

The results in these two experiments are given in tables 4 and 5.

TABLE 4.—Average Yields of Crops in Rotation of Corn and Soybeans in Renewed Experiments. (Series C.)

Plot No.	Treatment*	Corn, Bus. Ave. 6 Crops	Soybeans, Bus. Ave. 4 Crops
1	O	55.5	13.7
2	P	56.2	13.6
3	O	56.1	13.9
4	K	54.2	13.5
5	N	57.5	13.4
6	O	55.2	12.8
7	PK	55.6	14.2
8	PN	58.9	15.7
9	KN	57.9	15.5
10	PKN	55.7	15.0

TABLE 5.—Yield of Corn in Continuous Culture, Renewed Experiments. (Series D.)

Plot No.	Treatment*	Corn, Bus. Ave. 11 Crops	Ave. for Same Years Corn was Grown in Rotation with Beans
1	O	39.7	43.7
2	N	46.1	51.2
3	P	39.8	42.8
4	K	37.0	39.2
5	O	37.6	39.8
6	PN	44.3	49.8
7	NK	47.2	52.2
8	PK	43.1	48.2
9	PKN	46.9	52.1
10	O	36.0	40.6

*O = no treatment; P = acid phosphate; K = potash; N = nitrate of soda.

The significant things about the yields in these two rotations are (1) that the yields with the heaviest fertilization in continuous corn culture are not as high as the unfertilized yields of corn in the rotation of corn and soybeans, and (2) that the yields on unfertilized soil in rotation are about as great as the best yields on fertilized soil. These yields and the yields in the three and four-year rotations show that with the proper use of crop residues (or manure) soils like this can be kept in a productive condition for general farm crops.

RAINFALL AND CROP YIELDS

Examination of the crop yields on the Lexington Soil Experiment Field shows that the plots receiving no crop residues or fertilizers have been practically as productive as those receiving fertilizers and crop residues. The highest average yield of corn on this field has been on plot 10 receiving no fertilizers or residues. It has been 55 bushels for the 15-year period 1911-1925. There has been little difference in the yield of the other crops on this plot and the treated plots. On other parts of the farm where 10 to 12 tons of manure per acre have been applied to the corn ground, in the same kind of rotation, the yield of corn has been almost identical over a ten-year period with the corn yield on plot 10 of the soil experiment field. The plots in the renewed experiments receiving the heaviest fertilizer treatment show about the same average yields as plot 10 referred to above.

Moisture is a serious limiting factor in the production of corn in Kentucky, no matter how fertile the soil may be. The total rainfall is generally great enough during the growing season, but its distribution is often such as to greatly limit the production of corn. In table 6 data are given showing the variations in total rainfall for June, July and August, and the variation in corn yields on plot 10 of the Lexington Soil Experiment Field for the years 1911 to 1925. For later discussion, yields of soybeans on plot 10 are given and yields of alfalfa on the farm. To determine whether the distribution of rainfall was "good" or "poor" for corn, the rainfall for June, July and August was charted by six-day periods and studied with reference to the yields of corn.

TABLE 6.—Showing Relation of Rainfall and Crop Yields.

Year	Rainfall Inches	Total Rainfall for July-Aug., Inches	Yield of Corn Per Acre, Bus.	Yield of Soybeans per Acre, Bus.	Yield of Alfalfa per Acre, Tons	Distribution of Rainfall with Respect to the Corn Crop
1911	June 3.01 July .92 Aug. 2.84 6.77	3.76	30.7			Poor
1912	June 2.15 July 4.70 Aug. 3.23 10.08	7.90	78.0	31.8	5.00	Good
1913	June 3.29 July 2.43 Aug. 1.00 6.72	3.43	39.3	10.8	2.23	Poor
1914	June 4.77 July 2.63 Aug. 4.69 12.09	7.32	40.9	23.8	2.96	Poor
1915	June 3.20 July 5.72 Aug. 6.03 14.95	11.75	79.5	34.8	4.47	Good
1916	June 5.33 July 1.72 Aug. 2.34 9.39	4.06	73.9	15.0	3.27	Good
1917	June 3.54 July 2.80 Aug. 1.94 8.28	4.74	70.3	12.0	2.87	Good
1918	June 3.61 July 2.01 Aug. 2.68 8.30	4.69	29.3	16.8	3.20	Poor

TABLE 6—Continued.

Year	Rainfall	Inches	Total Rainfall for July-Aug. Inches	Yield of Corn Per Acre, Bus.	Yield of Soybeans per Acre, Bus.	Yield of Alfalfa per Acre, Tons	Distribution of Rainfall with Respect to the Corn Crop
	June	4.49					
1919	July	2.28	4.67	61.9	14.0		Good
	Aug.	2.39					
		9.16					
	June	2.39					
1920	July	1.73	8.44	76.5	21.2	2.84	Good
	Aug.	6.71					
		10.83					
	June	2.16					
1921	July	1.04	4.92	20.6	19.0	3.05	Poor
	Aug.	3.88					
		7.08					
	June	2.44					
1922	July	2.13	4.33	28.1	11.6	6.48	Poor
	Aug.	2.20					
		6.77					
	June	3.55					
1923	July	5.01	9.03	79.9	15.6	6.37	Good
	Aug.	4.02					
		12.58					
	June	4.04					
1924	July	2.77	5.05	60.9	12.4	5.45	Good
	Aug.	2.28					
		9.09					
	June	3.96					
1925	July	3.63	4.78	55.9	9.8	4.27	Fair
	Aug.	1.15					
		8.74					
	Average			55.0	17.8	4.00	

Attention is called to the yield of soybeans for the same period, the average being 17.8 bushels against 55 bushels of corn. While we do not have data on the yield of soybean hay over the same period on the Station farm, such data as we have makes it safe to state that an average yield of two tons of soybean hay can be expected on bluegrass soils in a fair state of cultivation. In view of these yields it seems reasonable to suggest a larger use of soybeans in the cropping system. Another point in favor of soybeans is the fact that wheat yields so much better after soybeans than after corn.

Attention is particularly called to the yields of alfalfa during this period. Alfalfa has ability to utilize moisture under the conditions in this region that perhaps no other crop has. Alfalfa ought to have a much larger place in the cropping system than it has, not only because of its value as a legume, but because of its excellent adaptability to this region.

MANURING EXPERIMENTS

The question arises in this connection whether there is not a limit beyond which it is not economical to try to maintain nitrogen in the soil under certain conditions and for certain crops. Specifically, where a rotation of crops is practiced containing a liberal proportion of legumes, what amount of manure will it pay to return and where in the rotation is the best place to use it? In order to throw some light upon this question a set of manuring experiments was begun in 1920. The plan of these experiments and the results to date are shown in table 7. The rotation is corn, wheat and clover. The experiments started with corn following a clover sod in 1920.

TABLE 7.—Average Yields of Crops Per Acre in Manuring Experiments, Station Farm, Lexington.

Serial Plot No.	Rate Application	Place of Application	Corn, Bus.				Wheat, Bus.		Clover, Lbs.	
			Ave. 6 Crops	Increase	Ave. 3 Crops	Increase	Ave. 4 Crops	Increase	Ave. 3 Crops	Increase
1	None	Manure on	52.4	.....	63.0	.....	23.2	.....	3373	.....
2	4 T	clover sod	60.5	8.1	74.7	11.6	28.9	5.3	3644	223
3	6 T	before break-	58.1	5.6	71.6	8.3	28.8	4.8	3597	128
4	8 T	ing for corn	58.4	5.8	72.3	8.9	29.1	4.7	3486	000–31
5	None		52.6	.....	63.5	.....	24.8	.....	3564	.....
6	10 T		59.9	6.8	75.6	11.8	29.6	4.5	3997	355
7	4 T	Manure on	60.6	7.0	74.6	10.5	27.5	2.1	3500	000–21
8	6 T	broken sod	62.4	8.2	76.6	12.1	29.2	3.4	3960	460
9	None	and disked in	54.7	.....	64.8	.....	26.1	.....	3479	.....
10	8 T	before plant-	61.8	7.9	77.6	13.4	30.1	4.2	3909	509
11	10 T	ing corn	60.4	7.2	75.4	11.8	30.3	4.5	3909	588
12	4 T	Manure on			68.8	5.8	29.1	3.5	3537	295
13	None	wheat early	51.6		62.4	.....	25.5	.....	3163	.....
14	6 T	in winter			66.2	3.6	30.1	4.3	4139	944
15	8 T				65.7	2.9	30.8	4.0	4071	844
16	4 T	Manure on			68.7	5.7			4161	902
17	None	young clover	52.3		63.2	.....	26.9	.....	3330	.....
18	6 T	soon after			68.6	5.0			4146	815
19	8 T	wheat harvest			67.9	3.9			4537	1205
20	None	Sweet clover instead of red clover	56.1		70.0	5.5	27.0		5647	2315
21	None		53.6		64.9	.....	25.6	.....	3333	.....

The manuring experiments have not been running long enough to justify conclusions. However there are certain tendencies that may be pointed out. One is the larger effect on corn of manure applied on the plowed ground as compared with plowing it under. Another is that the residual effect on wheat of manure applied in the two ways is slightly greater for the manure plowed under.

Another is that in the present state of fertility the smaller applications seem about as effective as the larger ones.

FERTILIZER TESTS ON BURLEY TOBACCO

Fertilizer tests have been made on Burley tobacco since 1917, a period of nine years. The rotation used is as follows: Tobacco two years with rye a cover crop between; wheat follows tobacco with clover and bluegrass (heavy seeding) sown on the wheat; clover and bluegrass for three years following wheat. Tobacco is thus grown on bluegrass sod the first year of the two-year tobacco period. All crops are removed, including the clover and bluegrass. Whatever growth of clover is made in the year of seeding and whatever second-crop clover is made after cutting for hay are left on the ground. No manure is used except on one plot as indicated in the table of results. Plots 10 to 17 were not introduced until 1920. The results are given in table 8.

TABLE 8.—Average Yields of Tobacco in Fertilizer Tests, Station Farm, Lexington.

Serial Plot No.	Fertilizers Per Acre Used Each Year on Tobacco	Yield, Lbs. Per Acre Ave. 1917-25	Increase Due to Fertilizers	Yield, Lbs. Per Acre 1920-25	Increase Due to Fertilizers
1	None	1445	.....	1355	.....
2	200 lbs. nitrate of soda	1611	169	1550	217
3	None	1439	.....	1310	.....
4	200 lbs. nitrate of soda 100 lbs. sulfate of potash	1638	226	1521	229
5	None	1384	.....	1274	.....
6	200 lbs. nitrate of soda 100 lbs. sulfate of potash 200 lbs. acid phosphate	1642	235	1495	186
7	None	1429	.....	1343	.....
8	200 lbs. nitrate of soda 100 lbs. sulfate of potash 200 lbs. acid phosphate 2 tons limestone (1st yr.)	1625	191	1468	134
9	None	1439	.....	1325	.....
10	100 lbs. sulfate of potash			1371	59
11	None			1298	.....
12	200 lbs. nitrate of soda 200 lbs. acid phosphate			1439	119
13	None			1339	.....
14	10 tons manure			1446	82
15	None			1389	.....
16	Cotton seed meal equivalent to 200 lbs. nitrate of soda			1483	62
17	None			1453	.....

ROTATION EXPERIMENTS WITH BURLEY TOBACCO

In 1916 rotation experiments were begun with Burley tobacco as the principal crop, for the purpose of trying to find a short rotation in which Burley tobacco of good quality could be grown.

The rotations, the fertilizer treatments used and the yields obtained are given in table 9. Each rotation and each treatment is run in duplicate. The yields are the average of the duplicates for the ten-year period.

TABLE 9.—Yields of Burley Tobacco in Rotation Experiments, Station Farm, Lexington.

Rotation Number	Rotations and Treatment	Tobacco, Lbs.
1	Wheat, clover and orchard grass for two years, tobacco, 20 tons manure per acre before tobacco	1543
2	Same as No. 1 except 200 lbs. nitrate of soda per acre instead of manure	1525
3	Same as No. 1 except no manure or fertilizer	1324
4	Wheat, clover, corn, tobacco, 20 tons manure before corn	1347
5	Alfalfa 2 years, corn, tobacco, 20 tons manure before corn	1304
6	Redtop 2 years, tobacco, 200 lbs. nitrate soda per acre on tobacco	1345
8	Soybeans, wheat, cowpeas catch crop and rye cover crop both turned under, tobacco. (Rye cover crop.)	1194

These experiments show that these rotations are not sufficient to maintain fertility for growing maximum tobacco yields without the use of fertilizers or manure. Over the nine-year period the "complete" fertilizer (plot 6, table 8) produced an average of 66 pounds more tobacco per acre than nitrate of soda alone. However, the superior effect of the complete fertilizer is confined to the first three years. Taking the averages of the last six years, the average yearly increase for nitrate of soda alone (plot 2) is 217 pounds per acre while the average yearly increase for the complete fertilizer (plot 6) is 186 lbs. per acre.

Another noteworthy fact is that 200 pounds of nitrate of soda per acre is as effective as a heavy application of manure in increasing the yield of tobacco (see plots 2 and 14 in table 8 and plots 1 and 2, table 9). Limestone (plot 8, table 8) has had no beneficial effect on either the yield or quality of the tobacco. There is no evidence in any of the experimental results on either Burley or dark tobacco that limestone directly benefits

tobacco, while there is some evidence that it slightly reduces the yield. However, there is evidence that limestone indirectly benefits tobacco through increasing the growth of clover where limestone is essential to the growth of clover.

The quality of tobacco on the fertilized plots in the fertilizer tests (table 8) was no better or worse than on the unfertilized plots.

In the rotation expermients (table 9) rotation No. 1 is clearly the best, both in quality and yield of tobacco. The three-year rotation (No. 6) of red top and tobacco gives about the same yield of tobacco as No. 4 and No. 5, which contain clover and alfalfa, respectively. For some reason not fully understood a grass sod seems much more favorable for tobacco than any other condition of soil. Rotation No. 1 (table 9) is almost as effective as the rotation in which tobacco is grown in the fertilizer test; namely, wheat, three years of clover and bluegrass, and tobacco, two years.

These results show conclusively that nitrogen is the most important fertilizing element to add to soils similar to those of the Station farm for growing tobacco. The mixture used on plot 6 (table 8) contains 31 pounds of nitrogen or 6.2 per cent. The tobacco fertilizers generally used contain about 2.5 per cent of nitrogen or 12.5 pounds of nitrogen in a 500-pound application of fertilizer, which is far too small for soils needing nitrogen. No doubt 50 pounds of sulfate of potash would have served as well in the mixture on plot 6 as 100 pounds. The following mixture is suggested for Burley tobacco in the central Bluegrass Region:

Nitrate of soda	800 lbs.	or 600 lbs. of sulfate of ammonia
Acid phosphate or basic slag	1000 lbs.	
Muriate or sulfate of potash	200 lbs.	
	2000 lbs.	

If sulfate of ammonia is used, 1,800 lbs. of the mixture is the equivalent of 2,000 lbs. when nitrate of soda is used. Basic slag should not be mixed with sulfate of ammonia but should be applied separately.

This mixture contains 6.2 per cent of nitrogen (equal to 7.5 per cent ammonia), 8 per cent of phosphoric acid and 5 per cent of potash. Stated in terms of a formula, it is a 7½-8-5 fertilizer. There were only two complete fertilizers in about 400 brands registered in Kentucky in 1925 that contained more than 4 per cent of ammonia. No experimental data in Kentucky on either Burley or dark tobacco would justify a higher percentage of potash than nitrogen. While the tobacco crop requires as much potash as nitrogen, or perhaps a little more, Kentucky soils are quite rich in potash and usually poor in nitrogen. Experiments over a long period of time and under varying conditions show that the soil potash is available enough to meet the needs of crops under nearly all conditions where a good rotation is being used and organic matter is being returned. Tobacco is a crop of high value per acre and a small increase in yield will justify the use of a small amount of potash. For example, 50 pounds of muriate or sulfate of potash should be bought for about $1.50. Ten pounds increase in the yield of tobacco would pay for this with tobacco at 15 cents per pound. A ton of mixed fertilizer containing 5 per cent of potash contains the equivalent of about 200 pounds of sulfate or muriate of potash.

It is recommended that complete fertilizers for Burley tobacco in the Central Bluegrass Region contain not less than 4 per cent of nitrogen and that the percentage of nitrogen should generally be as high as the percentage of potash or higher.

The fertilizer requirements of tobacco on soils of different degrees of fertility can usually be provided for as well by varying the amount of a good formula as by varying the formula. Any excess of phosphorus and potassium above the needs of the tobacco crop will be held in the soil and will be available to succeeding crops.

Since farmers are better able to judge of the productiveness of their soils in yields of corn than of other crops the following suggestions are made for applications of fertilizers for tobacco:

If the soil will produce in a season of good rainfall,

30 to 40 bus. of corn per acre use 500 to 750 lbs. of fertilizer per acre
40 to 60 bus. of corn per acre use 300 to 500 lbs. of fertilizer per acre
60 to 80 bus. of corn per acre use 300 lbs. of fertilizer per acre

On the better types of bluegrass soils somewhat above medium fertility, it is quite probable that an application of nitrate of soda or sulfate of ammonia will be as effective as a complete fertilizer. However, nitrogen fertilizers should not be used alone except on soils known to be rich in phosphorus.

As much as 500 pounds of mixed fertilizer per acre may be used in the row if it is well mixed with the soil. A satisfactory practice is to use 200 pounds in the row and the remainder broadcast. With applications of more than 500 pounds per acre it may as well all be applied broadcast.

It is strongly recommended that tobacco be grown only upon land kept in the best of condition through the use of clovers and grass. Tobacco of high quality can be produced only in this way. No kind of fertilization with commercial fertilizers will take the place of a soil made fertile through the proper use of legumes and manure.

Fertilizers used upon less productive land than that upon which these tests were conducted would no doubt give much larger increases.

USE OF NITRATE OF SODA ON TOBACCO

During the five-year period, 1920 to 1924, tests were made to determine the effect of varying amounts of nitrate of soda on Burley tobacco.

The tobacco was grown on ground that had been used in a regular rotation of corn, soybeans, wheat and clover since about 1910. Approximately ten tons of manure per acre was used on the clover sod for corn. The tobacco was grown on part of the field following corn. Each test was repeated three times each year.

TABLE 10.—Yields of Tobacco Treated With Different Forms and Amounts of Nitrogen Fertilizer.

Treatment (Rate Per Acre)	Yield Per Acre, Lbs.							
	1920	1921	1922	1923	1924	Ave. 1920-24	Ave. 1920-23	Ave. 1922-24
None	1316	1773	953	1169	1124	1267	1303	1082
100 lbs. nitrate of soda	1410	1710	1084	1169	.....	.....	1343	.....
200 lbs. nitrate soda	1309	1770	1061	1343	1221	1341	1371	1208
400 lbs. nitrate soda	1457	1797	1141	1430	1286	1422	1456	.....
Ammonium sulfate 150 lbs. per acre equivalent to 200 lbs. nitrate of soda	.....	.....	1063	1322	1219	.....	.....	1201

The 200 pounds and the 400 pounds of nitrate of soda applications were carried through five years. The average yearly increases to tobacco for the two rates were 74 pounds and 155 pounds per acre respectively.

The 100 pounds, the 200 pounds and the 400 pounds applications can be compared through the 4-year period 1920 to 1923. The average yearly increases of tobacco per acre are 40 pounds, 68 pounds and 153 pounds, respectively.

Two hundred pounds of nitrate of soda and the nitrogen equivalent of ammonium sulfate (150 lbs.) can be compared through the 3-year period 1922 to 1924. The average annual increases are 126 pounds and 119 pounds of tobacco per acre, respectively.

TESTS OF NITROGEN FERTILIERS ON WHEAT

The yield of wheat in Kentucky following corn is often unsatisfactory even on fertile land. On the Experiment Station farm at Lexington the yield of wheat following corn seldom averages over 20 bushels per acre on land that is capable of making 70 to 80 bushels of corn per acre in a favorable season. Wheat following tobacco on land in the same condition will yield from 5 to 10 bushels more per acre and following soybeans will yield about 5 bushels more. It was thought probable

that the relatively low yields on corn land are due to a deficiency of available nitrogen A heavy yield of corn requires a large amount of nitrogen and may leave the soil deficient in available nitrogen. It may be that the corn crop in some way inhibits the activity of the nitrifying organisms. It is possible that there is some other effect of corn that prevents a good growth of wheat. The probability that a deficiency of available nitrogen is the cause for low wheat yields following corn is further indicated by the fact that top dressing with commercial nitrogen in early spring gives large increases in yields in many cases. In 1916 on the Experiment Station farm the use of 100 pounds of nitrate of soda per acre in the spring increased the yield of wheat from 21.4 bushels per acre to 31.9 bushels per acre, while the fall application had no effect whatever. This was on land that had been heavily manured before planting to corn, and had made about 70 bushels of corn per acre, the year before.

The experiments with nitrogen fertilizers on wheat on the Station farm were undertaken to compare the relative effectiveness of fall and spring applications. These experiments were begun in 1918. In the following table are given the results of the five tests for five years.

TABLE 11.—Yields of Wheat from Fall and Spring Applications of Nitrate of Soda. (Bushels per acre.)

Year	No Treatment	100 Lbs. Nitrate of Soda Per Acre in Fall	100 Lbs. Nitrate of Soda Per Acre in Spring
1918	30.0	26.0	23.3
1919	19.5	15.2	24.8
1920	7.5	10.0	15.3
1922	32.5	32.7	33.2
1923	17.6	18.3	21.5
Average	21.4	20.4	23.6

Wheat on the nitrogen fertilizer plots winter-killed almost completely in 1924 and too badly to leave in 1925. The spring of 1918 was very favorable for wheat and a heavy growth of

straw was produced even on corn land. Much wheat on tobacco land lodged badly. On the nitrogen test plots the straw fell badly on the plots receiving nitrogen, both in the fall and spring, thus making the yield lower than on the unfertilized plots. Similar conditions prevailed in 1922.

The tests indicate quite conclusively that nitrogenous fertilizers applied to wheat in the fall are generally ineffective. As to the profits of spring applications of nitrates on such land, the results are not very conclusive. They show that in certain seasons the fertilizer gives large increases in yields, while in seasons more favorable for wheat they may not give an increased yield. Observation has shown that the large increases are most likely to occur when the wheat comes through the winter in poor condition but with a good stand, and especially when this condition is accompanied by poor growing weather for wheat in early spring. The average increase in yield from the application of 100 pounds of nitrate of soda in the spring has been only 2.2 bushels per acre. The maximum increase was 7.8 bushels in 1920. Excluding the results for 1918, the average increase has been 4.5 bushels per acre. This is sufficient to just about pay for the fertilizer and the cost of application at the prices that have prevailed during recent years for both wheat and fertilizer. If good judgment is used as to the conditions under which nitrogen fertilizer may be effective and the cost of the fertilizers and the price of wheat are kept in mind a profit may be obtained from their use on wheat following corn.

Nitrate of soda used as a top dressing on wheat following soybeans or tobacco in a rotation in which clover is grown is of doubtful value. As an average of 43 tests with nitrate of soda on wheat following tobacco at Mayfield, Greenville and Campbellsville, extending over periods of four to eleven years, 100 pounds of nitrate of soda per acre used as a top dressing in the spring has produced an average increase of 1.8 bushels per acre. The maximum of any test was an average increase of 3.6 bushels per acre as an average of eleven years.

As an average of 30 tests on wheat following soybeans at Russellville, Lone Oak and Mayfield 100 pounds of nitrate of

soda used as a top dressing in the spring there was no increase in yield. At Russellville there was an average increase of 2.3 bushels per acre for nine years, this being the highest of any test.

In a rotation of corn, wheat, and clover at Campbellsville, as an average of sixteen tests extending over a period of four years, the average increase of wheat from a top dressing of 100 pounds of nitrate of soda has been 3.7 bushels per acre.

In all of these tests except on the Station farm at Lexington the soil was liberally treated with a phosphate fertilizer and in most of them the soil was limed.

It is useless to apply a nitrogen fertilizer to a soil deficient in phosphorus.

EXPERIMENTS WITH NITROGEN FERTILIZERS ON HEMP

These experiments were started in 1916 when hemp was still considered a profitable crop and several thousand acres were grown in Central Kentucky. The acreage had been rapidly declining, however, due in part at least to the competition of tobacco. It was generally believed that hemp could be grown profitably only on land in the most productive condition, such as virgin soils or bluegrass sods of long standing. This is the character of land necessary for the production of high grade White Burley tobacco and as the amount of such land available on the average farm is limited, it was naturally reserved for tobacco, because the returns per acre are much larger from tobacco than from hemp. These tests were undertaken to determine the effect of nitrogen fertilizers on hemp grown on land less desirable for tobacco. Nitrogen alone was used because hemp requires large amounts of this element and the soils of the bluegrass region are well supplied naturally with the mineral elements of plant food. For the first three years of the test the same plots were used, except a duplicate test in 1917. The soil was in fair condition, having made about sixty bushels of corn per acre the year previous to sowing to hemp. Tests for the latter three years were made on land used in a rotation of corn, soybeans, wheat and clover. The hemp followed corn in each

case, taking the place of soybeans in the rotation. The land was manured for corn at the rate of about ten tons per acre. Either frequent checks were used or the tests were made in triplicate. The averages of the tests for each year are given in table 13.

TABLE 12.—Yields of Hemp Fiber Per Acre. Nitrogen Fertilizer Tests.

Year	No Treatment	100 Lbs. Nitrate of Soda Per Acre	200 Lbs. Nitrate of Soda Per Acre	300 Lbs. Nitrate of Soda Per Acre	150 Lbs. Sulfate of Ammonia (Nitrogen Equivalent to 200 lbs. nitrate of soda)
1916	1170	1634			
1917	966	1306			
*1917	1180	1504	1838		
1918	680	960			
1919	660	810	1030	1410	1050
1921	650		1060		980
1922	866	1060	1206	1214	1146

*This test was on land following corn.

It will be noted that yields differ very greatly from year to year. Hemp yields are greatly affected by rainfall during April and May, and in most cases the years of low yields are those in which the rainfall was light in these months or its distribution unfavorable.

For the six tests in which 100 pounds of nitrate of soda per acre was used, the average yearly increase of fiber was 292 pounds per acre, the average yield of the unfertilized hemp being 920 pounds per acre.

A comparison of 100 pounds and 200 pounds of nitrate of soda can be made for three years. The average yearly increases in fiber are 223 pounds and 456 pounds per acre respectively for the two rates. The average yield of unfertilized hemp for these three years was 902 pounds of fiber per acre.

A comparison can be made of 100 pounds, 200 pounds, and 300 pounds of nitrate of soda and 150 pounds of sulfate of ammonia for two years. The increases in fiber are 172 pounds, 355

pounds, 549 pounds and 335 pounds per acre for the respective treatments. The average yield of unfertilized hemp for these two years was 763 pounds per acre.

A comparison can be made of 200 pounds of nitrate of soda and 150 pounds of sulfate of ammonia for three years. The average yearly increases in fiber are 374 pounds and 334 pounds per acre respectively.

The experience of one of the largest hemp growers in the state is that 300 pounds per acre of nitrate of soda or sulfate of ammonia per acre can profitably be used on land that is not in a highly fertile condition.

EXPERIMENTS ON THE RATE OF SEEDING HEMP

There has always been considerable difference of opinion as to the best rate for seeding hemp. The Station has data for two years which are given below: The hemp was grown in triplicate plots.

Rate of Seeding	Yield of Fiber Per Acre 1921 Lbs.	Yield of Fiber Per Acre 1922 Lbs.
2 pecks	1153	1090
3 pecks	1293	1250
4 pecks	1321	

Apparently from the standpoint of yield it paid to sow three pecks of seed. There was no appreciable difference in the quality of the fiber.

THE USE OF HEMP FOR ERADICATING WILD ONIONS

Hemp is one of the most effective crops known for smothering weeds. It has even been credited with the mastery of quack grass and Canadian thistle. Wild onions are one of the most difficult weeds to eradicate and one of the most troublesome in Kentucky. A test was started in 1916 to determine if they could be eradicated by growing hemp. A plot of land that had

been infested with wild onions for many years was chosen for the experiment. It was plowed in early spring and sowed to hemp. This treatment was repeated for three years, at the end of which time the onions were practically eradicated. At the end of the second year few were left, and it is believed that by plowing in late fall instead of spring, the onions may be completely destroyed in two years.

CULTIVATION EXPERIMENTS WITH CORN

Tests were made on different methods of cultivating corn through the ten-year period of 1911 to 1920. The corn was grown in a rotation of corn, soybeans, wheat and clover. The ground on which the tests were made was manured each year at the rate of approximately 10 tons per acre. Each method of cultivation was repeated three times each year. Weeds were kept down to practically the same extent in all methods of cultivation.

The average yields for ten years for the various methods of cultivation are as follows:

	Bus. Per Acre
Shallow 6 to 8 times	55.5
Deep 6 to 8 times	56.2
Shallow 3 to 4 times	55.8
Deep 3 to 4 times	56.1
No cultivation, weeds scraped	52.9

The shallow cultivation was done with small shovel cultivators and averaged about two inches deep. The deep cultivation was done with a riding cultivator or "double shovel" and averaged about four inches deep. On the "no cultivation" plots the weeds were scraped with very sharp hoes with very little disturbance of the soil.

The conclusion that must be drawn from these experiments is that the primary effect of cultivation of corn on soils of this type is the elimination of weeds.

The conservation of moisture by the so-called mulching effect of cultivation is a matter of small importance after corn has reached a height of some 15 to 20 inches. At this stage of growth the roots have spread through the soil to such an extent

that they arrest and use the moisture as it rises from the lower depths of the soil. There is a difference of 2.9 bushels of corn between the scraping method and shallow cultivation three to four times. This difference is due chiefly to two or three years when drouth set in about the time corn was planted. When soil is not occupied by roots of growing crops cultivation will conserve moisture.

In nearly all similar experiments in other states deep cultivation has lowered the yield. The difference in the behavior of corn under deep cultivation here and elsewhere is to be explained by difference in soils. The soils here become richer in phosphorus and calcium as the depth increases. Consequently when deep cultivation forces a deeper rooting habit the crop is not limited in its supply of mineral plant food as is the case in those soils whose lower depths are deficient in these mineral elements which is true for most soils.

The elimination of weeds is so highly important that it may be safely stated that that method of cultivation is most effective which most effectively eliminates weeds. It is needless to say that weeds are most easily destroyed when young and that cultivation should be given whenever weeds appear. It is also worth while to cultivate following rains when corn is small for the purpose of conserving moisture.

These results are in harmony with many similar experiments throughout the United States.

CORN AND SOYBEANS PLANTED TOGETHER

For seven years the Experiment Station has been making tests of different methods of planting corn and soybeans together. This is a matter of considerable importance because the planting of corn and beans together for the purpose of hogging down is rapidly increasing. In the period there were two very good years for corn, two poor ones, and three fair ones. Some of the methods were not carried through the entire period. Plantings by each method were made in triplicate each year.

TABLE 13.—Average Yields of Corn and Soybeans in Different Methods of Combined Plantings.

	Yield of Corn Per Acre. Bus.	Yield of Beans Per Acre. Bus.	Combined Yield. Bus.
Corn alone. Ave. 7 yrs.	45.1	.....	.....
Beans alone. Ave. 7 yrs.	.....	19.7	.....
Corn with beans in each hill of corn. Ave. 7 yrs.	38.3	3.7	42.0
Corn with 2 hills of beans to each hill of corn. Ave. 4 yrs.	32.7	5.0	37.7
Corn alone. Ave. for same 4 yrs.	43.5	.....	.....
Beans alone. Ave. for same 4 yrs.	.....	19.5	.....
Alternate rows of beans and corn, 36 inch rows. Ave. 5 years.	20.7	10.2	30.9
Corn alone. Ave. for same 5 years.	37.3	.....	.....
Beans alone. Ave. for same 5 years.	.....	19.1	.....
Beans drilled thick in corn rows. Ave. 6 yrs.	26.6	10.8	37.4
Corn alone. Ave. for same 6 yrs.	45.5	.....	.....
Beans alone. Ave. for same 6 years.	.....	20.3	.....

There was not a year in the seven when beans planted in corn at any of the rates used did not reduce the yield of corn. Roughly stated, for each bushel of beans grown in combined plantings there was a reduction in the yield of corn of two bushels.

However, the value of the combined yield may be greater than the yield of corn alone. This is true where it is desired to hog down the corn, because some of these ratios are practically a balanced ration. The most desirable ratio for hogging down is one or two hills of beans to each hill of corn.

The nitrogen gathered by the beans is a consideration. Each bushel of beans produced represents about five pounds of nitrogen gathered from the air, which is left in the soil if the beans are hogged down.

These and similar experiments elsewhere contradict the belief largely held by farmers that peas and beans grown in corn do not interfere with the corn and that they may in some cases increase the yield.

THE BEREA SOIL EXPERIMENT FIELD

The Berea Soil Experiment Field is conducted cooperatively with Berea College on land belonging to Berea College. It is located about two miles east of Berea at the base of the knobs which border the Bluegrass Region. This chain of knobs is known in the western part as Muldraugh's Hill. The soils of this area are derived chiefly from shales and are of a light color, generally quite acid, low in phosphorus and nitrogen, and poorly drained, especially where the land is level or nearly level.

Work was begun on this field in 1913. A rotation of corn, soybeans, wheat and clover was tried at first, but the soil was so poorly drained that wheat and clover were either killed outright during the winter or were injured so badly that the yields were very poor. A tile drainage system was installed in the spring of 1917. Wheat would withstand the winters after the drainage system was installed, but the yields were not satisfactory, being only about nine bushels per acre as an average for three years.

Wheat was dropped out of the rotation and rye was substituted as a cover crop following soybeans. The clover is sown on the rye, and the rye is clipped about the time it begins to head. In farm practice it could well be pastured but in experimental work this cannot be done.

Limestone was used on the limed plots at the rate of two tons per acre when the ground was prepared for corn. This was done for two rounds of the rotation. Each limed plot has therefore received four tons of limestone. After two rounds of the rotation the use of limestone was discontinued.

For the first two rounds of the rotation acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at the rate of 1600 pounds per acre per rotation. After the second round of the rotation these amounts were reduced by one-half.

Except for the first three years, muriate of potash or its equivalent in other potash salts has been used at the rate of 200 pounds per acre per rotation. The rate for the first three years was 400 pounds per acre.

All fertilizers are applied on the corn ground and no more are added during the rotation period. Except for the rock phosphate, the fertilizers might as well be divided equally among the first three crops of the rotation.

Beginning with 1917, manure was used at the rate of six tons per acre on all plots except No. 1, when the series was planted to corn, and continued at this rate on the corn series for one round of the rotation, after which it was used on each plot except No. 1 at a rate equal to the weight of the crops removed from the four corresponding plots the previous year. (This is an amount of manure that can be made from the feeding of crops). The crop yields on this field are given in table 14.

TABLE 14.—Average Yields of Crops Per Acre. Berea Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus. Ave. 13 Crops	Soybean Hay, Lbs. Ave. 12 Crops	Clover† Hay, Lbs. Ave. 7 Crops	**Increases Due to Treatments			
					Treatment Producing the Increase	Corn	Soybeans	Clover
1	None	14.3	1619	76		-----	-----	-----
2	LM	38.9	3730	649	L	10.0	847	233
3	M	28.9	2883	416	M	14.6	1264	340
4	APM	37.5	3490	670	AP	8.6	607	254
5	RPM	35.6	3295	760	RP	6.7	412	344
6	LAPM	43.3	4416	2090	LAP	17.5	1395	1664
7	LRPM	42.5	4363	1754	LRP	16.7	1342	1328
8	M	25.8	3021	426		-----	-----	-----
9	LAPKM	44.2	4705	2016	LAPK	18.4	1684	1590
10	LRPKM	41.3	3966	1556	LRPK	15.5	945	1130

*L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; M = manure.

**The increase for manure is obtained by subtracting the yield of plot 1 from the yield of plot 3. The increases for limestone and fertilizers are obtained by subtracting the yields of the nearest manured plots (Plots 3 and 8). The increases attributed to limestone and the various fertilizers are therefore the increases produced by these treatments on manured land.

†Clover failed in 1923 on account of winter killing. This year is not included in the averages.

The yields of corn and soybeans on this field have been quite satisfactory but the yields of clover have not been. On a

demonstration plot near the experimental plots it has been shown that sweet clover will thrive on this soil. Lespedeza also does well. Beginning with the seeding of 1925 a mixture of sweet clover, red clover, alsike clover, lespedeza and timothy will be used, and should give much more satisfactory yields than the mixture of red and alsike that have been previously used.

If corn and soybeans had each been grown twice in the four-year rotation period instead of trying to grow winter grain and red clover, it would have been much more profitable.

These results show the very great need of both lime and phosphate fertilizers on this soil. These results will apply to all soils lying adjacent to the Knobs section.

THE FARISTON SOIL EXPERIMENT FIELD

The Fariston Soil Experiment Field is located five miles south of London on the Louisville and Nashville Railroad. The soil is a silt loam bordering on fine sandy loam and is derived from shale and sandstone. The soil of this field represents a considerable area of soil lying in a strip along the western side of the eastern coal field and extending from the Ohio River in Boyd County to the Tennessee line in Whitley County.

The soil of this field was very badly worn when work was begun on it in 1916. The analysis of the soil at that time showed that it contained approximately the following amounts of nitrogen, phosphorus and potassium in two million pounds of soil (an acre to the depth of about seven inches).

Total nitrogen	2,300 lbs.
Total phosphorus	820 lbs.
Total potassium	24,400 lbs.

The soil is distinctly acid, and is deficient in nitrogen and phosphorus.

A four-year rotation of corn, soybeans, rye and clover is used. A rye cover crop is used between the corn and soybeans and is plowed under. A mixture of red and alsike clover has been seeded on the rye that follows the soybeans. The rye is

clipped down after it is well jointed. Since experimental plots cannot be pastured that is the nearest approach to pasturing that can be used.*

The series of plots from which clover is harvested is broken immediately after harvest and seeded to cowpeas or soybeans which are turned under and followed by a rye cover crop. This is turned under in preparation of the series for corn. An exception is that the peas or beans are removed from plot No. 2. The cornstalks are left on all plots except No. 2. No manure has been used on this field for the reason that it cannot be obtained for regular use.

Fertilizing materials have been used at the following rates:

Limestone, 2 tons per acre, when corn is planted. This was done for two rotations, after which the use of lime was discontinued. Thus each limed plot has received 4 tons of limestone per acre.

Acid phosphate, 800 pounds per acre for the rotation, one-half on the corn ground and one-half when the rye is sown.

Rock phosphate, 1,600 pounds per acre for the rotation, applied on the corn ground.

Steamed bone meal (28 per cent) 420 pounds per acre, used in the same way as acid phosphate.

Muriate of potash (or its equivalent) 200 pounds per acre, used in the same way as acid phosphate.

Complete fertilizer (2-8-2 on plot 15) 800 pounds per acre, used in the same way as acid phosphate until 1922. After this the following mixture was used on the corn and on the rye:

Acid phosphate	400 lbs.
Nitrate of soda	100 lbs.
Muriate of potash	30 lbs.

This is approximately a 3½-12-3 formula. When the 2-8-2 formula was used one-half of the application for corn was put

*For four years wheat was used, but the soil is so poorly adapted to wheat and the yields were so unsatisfactory that rye was substituted. The average yield of wheat for four years on the plot treated with limestone and acid phosphate was 12 bushels per acre and the average on the untreated soil was 3.2 bushels per acre.

in the hill and one-half was applied broadcast. In the latter mixture the nitrate of soda, the muriate of potash and 100 lbs. of the acid phosphate are applied in the hill.

Beginning with 1925 the second half of the fertilizer applications will be used on the soybeans instead of the rye.

The treatments used and the crop yields on this field are given in table 15.

TABLE 15.—Crop Yields Per Acre, Fariston Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus.		Soybean Hay, Lbs.		Clover Hay, Lbs.	
		Ave. 10 Crops	Inc.	Ave. 10 Crops	Inc.	Ave. 7† Crops	Inc.**
1	O	10.4	.....	1350	.....	110	
2	O	9.1	.....	1403	.....	.....	
3	L	17.8	7.7	2083	583	391	
4	O	10.0	.....	1575	.....	202	
5	RP	32.9	23.0	2856	1368	749	
6	BM	31.0	21.1	2712	1312	707	
7	O	9.8	.....	1312	.....	83	
8	AP	25.6	16.7	2205	948	788	
9	APK	28.6	20.6	2272	1070	959	
10	O	7.1	.....	1147	.....	34	
11	LAP	39.8	31.7	3743	2542	1597	1540
12	LAPK	40.7	31.7	3923	2668	2015	1927
13	O	10.2	.....	1309	.....	100	
14	LRP	26.6	16.1	2591	1345	846	
15	NPK	27.0	17.5	2053	871	548	
16	O	9.1	.....	1118	.....	76	

* O = no treatment; L = limestone; RP = rock phosphate; AP = acid phosphate; BM = bone meal; K = "muriate" of potash; NPK = "complete" fertilizer.

**Crop increases have been calculated by assuming a uniform variation in soil between check plots.

†Clover a failure in 1924, not included in averages.

As will be seen from the yields of the check plots, this soil was in a very unproductive condition. It is so devoid of organic matter that it packs during the winter, making it poorly adapted to wheat and clover. The yields of clover (mixture of red and alsike) are disappointing on the best plots. The highest yields obtained were 2,750 pounds per acre on plot 11 and 2,700

pounds on plot 12 in 1920. Demonstrations on non-experimental plots on the field show that sweet clover thrives well on this soil when it is limed and treated with acid phosphate. It is recommended that on the badly worn soils of this region sweet clover be grown until the soil is improved enough to grow red clover. The experiments on the London Experiment Field (reported in Bulletin 199) show that when the soil is not so badly worn red clover does well on treated soil. On this field an average of four tests covering two years, gave an average of 3,200 pounds per acre with a failure on the untreated soil. Generally it is useless to attempt to grow clovers on these soils without treating them with lime and phosphate.

Beginning with 1925 a mixture of timothy, red and alsike clovers and lezpedeza will be used instead of clover alone.

The results on this field show the great need for lime and phosphate for all crops. They also show the superiority of rock phosphate and steamed bone meal where lime is not used. They further show that rock phosphate is not effective when used with lime.

There have been fair results from potash in addition to acid phosphate on unlimed ground, but scarcely enough to pay for the amount used. It might be that smaller amounts, say 30 or 40 pounds of "muriate" of potash per acre a year would produce as large results as the heavier application.

It is reasonable to believe that could manure have been obtained and returned in quantities that could have been made by feeding the crops that have been taken from this field the results would have been much better. Results from fields where manure has been used show largely increased yields from its use.

The highest yield of corn obtained was in 1921, on plot 11, when it made 50.9 bushels per acre, against 6.3 bushels on the nearest untreated check (plot 7).

An interesting development on this field as the experiments become older is the effect of rock phosphate on unlimed ground in comparison with acid phosphate and limestone and acid phosphate.

The following summary shows this effect:

	Acid Phosphate	Rock Phosphate	Limestone Acid Phosphate
Ave. yield of corn 1st 5 yrs.	29.8 bus.	32.0 bus.	40.4 bus.
Ave. yield of corn next 5 yrs.	21.5 bus.	33.8 bus.	39.3 bus.
Ave. yield of soybean hay 1st 5 yrs.	1668 lbs.	2068 lbs.	3000 lbs.
Ave. yield of soybean hay next 5 yrs.	2742 lbs.	3644 lbs.	4486 lbs.

The results of this field are applicable to the entire mountain section of the State.

THE CAMPBELLSVILLE SOIL EXPERIMENT FIELD

The Campbellsville Soil Experiment Field was established in 1919. It is located about a mile and a half from Campbellsville. The soil is derived from the Waverly limestone and represents a large area of land lying in southern and eastern Kentucky which includes parts of Allen, Adair, Barren, Boyle, Bullitt, Casey, Clinton, Cumberland, Estill, Green, Jefferson, Larue, Lewis, Lincoln, Madison, Marion, Menifee, Metcalfe, Monroe, Nelson, Powell, Pulaski, Rockcastle, Rowan, Taylor and Wayne. While not the whole of these counties is occupied by the Waverly Limestone formation, the results on this field are applicable to the whole of the counties with the exception of the better parts of Boyle and Madison Counties.

The average of the analyses of a number of samples from this field show the soil to contain approximately the following amounts of nitrogen, phosphorus and potassium in two million pounds of soil. (The weight of an acre to the depth of about seven inches).

Total nitrogen	2,375 lbs.
Total phosphorus	1,100 lbs.
Total potassium	13,000 lbs.

The soil shows only very slight acidity. This is doubtless due to the prevalence of marl in the formations from which this soil is derived. Numerous marl deposits are found in this

region that are yet weathering out and supplying the soils that lie below them with lime. These deposits account for many reports of the successful growth of red and sweet clovers without liming the soil.

Three series of 19 plots each are devoted to fertilizer tests in a rotation of corn, wheat and clover. Three series of 13 plots each are devoted to fertilizer tests in a rotation of tobacco, wheat and clover. Three series of 16 plots each are devoted to a test of rates of application of acid phosphate and rock phosphates in a rotation of corn, wheat and clover.

Fertilizers and limestone have been used as follows: Where limestone is shown it has been applied at the rate of two tons per acre for two rounds of the rotation, after which its use was discontinued. Except where otherwise indicated, acid phosphate has been used at the rate of 600 pounds per acre, applied on the corn or tobacco ground for the three crops of the rotation. Basic slag has been used at the same rate. Muriate of potash or its equivalent has been used at the rate of 150 pounds per acre per rotation, applied on the corn or tobacco ground for the three crops of the rotation. Nitrate of soda has been used at the rate of 100 pounds per acre on corn and wheat, and 200 pounds per acre for tobacco, except the first crop, when it was used at the rate of 100 pounds per acre.

The various treatments used and the crop yields obtained on this field are shown in tables 16, 17 and 18.

It was planned to return manure to certain plots in proportion to the crops they produced, but it has not been possible to obtain the manure. As it is not practical to keep livestock on a small experiment field, it becomes necessary to buy whatever manure is used. Since manure could not be used, the following legume crops have been used for soil improvement.

A cowpea crop was grown in 1919 and turned under preceding the corn and tobacco crops of 1920 in all three sets of experiments. Crimson clover preceded and was turned under for these crops in 1921. A second crop of clover was turned under preceding these crops for 1922 and 1923.

In 1923 and 1924 the clover was almost a failure in the first tests referred to and was turned under and followed by cowpeas which were turned under for the corn crop of 1924.

In the tobacco rotation and in the rate of phosphate tests in 1923 the clover was fair and was harvested and followed by cowpeas which were turned under for the tobacco and corn crops of 1924. In 1924 fire burned over a number of clover plots in the tobacco rotation and in the phosphate tests, and so injured it that the clover series were plowed up and seeded to cowpeas which were turned under.

TABLE 16.—Crop Yields in Fertilizer Tests in Corn-Wheat-Clover Rotation, Campbellsville Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus.		Wheat, Bus.		Clover, Lbs.	
		Ave. 6 Crops	Increase	Ave. 4 Crops	Increase	Ave. 3 Crops	Increase
1	O	16.9	.....	4.4	.....	623	.....
2	O	16.1	—1.0	3.6	—0.2	587	—46
3	L	22.7	5.4	5.0	1.7	923	280
4	O	17.4	.....	2.7	.....	653	.....
5	AP	38.7	17.4	7.6	3.9	1480	749
6	APK	42.6	17.4	8.8	4.2	1947	1138
7	O	29.0	.....	5.6	.....	887	.....
8	APN	46.3	19.1	11.5	6.4	1860	1002
9	APKN	45.3	20.0	12.7	8.2	1867	1038
10	O	23.4	.....	4.0	.....	800	.....
11	BSKN	42.9	20.7	11.1	7.1	1803	983
12	LAP	45.9	25.0	8.2	4.3	2303	1463
13	O	19.7	.....	3.9	.....	860	.....
14	LAPK	47.8	27.1	10.4	6.3	2150	1331
15	LAPN	47.0	25.4	13.4	9.1	2193	1415
16	O	22.6	.....	4.5	.....	737	.....
17	LAPKN	46.3	24.4	14.3	9.9	2573	1849
18	LBsKN	44.2	23.1	13.6	9.2	2060	1350
19	O	20.4	.....	4.3	.....	697	.....

* O = No treatment; L = limestone; AP = acid phosphate; K = potash; N = nitrate of soda; Bs = basic slag.

Crop increases have been calculated by assuming a uniform variation in soil between check plots.

TABLE 17.—Crop Yields Per Acre in Fertilizer Tests in Tobacco-Wheat-Clover Rotation, Campbellsville Soil Experiment Field.

Serial Plot No.	Treatment*	Tobacco, Lbs.		Wheat, Bus.		Clover, Lbs.	
		Ave. 4 Crops	Increase	Ave. 4 Crops	Increase	Ave. 4 Crops	Increase
1	O	402	.....	8.3	.....	897	.....
2	AP	861	432	16.3	7.9	2013	1078
3	APK	855	399	15.8	7.4	1782	810
4	O	483	.....	8.5	.....	1010	.....
5	APN	908	436	18.0	9.5	1941	919
6	APKN	1053	593	18.2	9.8	2514	1479
7	O	449	.....	8.4	.....	1047	.....
8	LAP	802	363	18.5	10.6	2796	1825
9	LAPK	879	449	18.1	10.6	2785	1889
10	O	420	.....	7.0	.....	820	.....
11	LAPN	785	347	18.9	11.4	2223	1392
12	LAPKN	1010	555	19.7	11.6	2733	1892
13	O	473	.....	8.6	.....	852	.....

* O = No treatment; AP = acid phosphate; K = potash; N = nitrate of soda; L = limestone.

TABLE 18.—Average Crop Yield Per Acre in the Phosphate Tests. Campbellsville Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus.		Wheat, Bus.		Clover, Lbs.	
		Ave. 6 Crops	Increase	Ave. 4 Crops	Increase	Ave. 4 Crops	Increase
1	O	16.6	.....	4.9	.....	696	.....
2	AP 300 lbs.	31.5	12.4	6.7	1.4	1140	361
3	RP 600 lbs.	35.3	13.8	8.9	3.2	1737	875
4	O	24.0	.....	6.1	.....	945	.....
5	AP 900 lbs.	43.2	19.2	10.6	4.8	2466	1568
6	RP 1800 lbs.	44.4	20.3	10.8	5.2	3150	2299
7	O	24.1	.....	5.3	.....	804	.....
8	L (AP 300 lbs.)	39.0	15.5	8.5	3.3	1518	678
9	L (RP 600 lbs.)	32.0	9.2	7.4	2.2	1409	533
10	O	22.2	.....	5.1	.....	912	.....
11	L (AP 900 lbs.)	48.9	26.5	12.8	7.7	3258	2341
12	L (RP 1800 lbs.)	39.6	17.1	10.0	4.8	1682	760
13	O	22.7	.....	5.2	.....	927	.....
14	†RP 1200 lbs.	40.7	18.2	8.5	2.8	2517	1590
15	†L (RP 1200 lbs.)	35.0	12.6	8.0	1.9	1542	615
16	O	22.2	.....	6.6	.....	927	.....

* O = No treatment; AP = acid phosphate; RP = rock phosphate; L = limestone.

†Plots 15 and 16 in this rotation are to be compared with plots 5 and 12 in Table 16.

The work on the field in 1919 was preliminary and yields of this year are not included in the report.

The soil was so badly worn that the wheat was a failure in 1920 and 1924.

As already stated the clover crop was practically a failure in 1923 and 1924 in the rotation represented in Table 16. This was without doubt due to the impoverished condition of the soil. In the tobacco rotation and in the rotation devoted to rate of phosphate applications the clover crop of 1924 was so injured by fire that caught in the dead crabgrass that it was not harvested.

Wheat was a failure in 1920, the first year it was due in the rotations. On account of the very badly worn condition of the soil, not enough survived the winter to make it worth harvesting by plots. Wheat was a failure again in 1924 on account of freezing out.

Tobacco was not planted in 1919, the year work was begun on the field. The crop failed in 1920 on account of drouth at setting time. No tobacco was set in 1921 on account of drouth, there being no season for setting until it was considered too late.

In studying the results of this field it should be kept in mind that the soil was in a very badly worn condition, as the yields on the check plots show.

The wheat yields are disappointingly low. Good wheat yields require a fertile soil, and the time this field has been in operation is too short for building up so thin a soil to a condition that will produce good wheat, especially when it has not been possible to use manure.

The results need little comment. The outstanding needs of this soil are the use of limestone and phosphate. However, limestone used alone produces very little effect. These experiments indicate that on soils of this type that are not limed, rock phosphate produces larger yields in general than acid phosphate when used at the rates shown in these comparisons. Generally rock phosphate can be purchased at about one-half the price (per ton) of acid phosphate. Weight for weight rock phosphate contains about twice as much phosphorus as acid phosphate.

The results also indicate that rock phosphate should not be used on soil that has been recently limed. Several years after liming it would probably be safe to use rock phosphate.

While potash and nitrogen in nitrate of soda have produced some increase in corn and wheat, it is scarcely enough to pay for the cost of the materials. Nitrate of soda costs from $3.75 to $4.00 per hundred pounds, and less than 100 pounds per acre is too small to have much effect. In this connection it is well to keep in mind that 100 pounds of nitrate of soda contains as much nitrogen as 900 pounds of 2-8-2 fertilizer and that 50 pounds of muriate of potash contains as much potash as 1,250 pounds of 2-8-2 fertilizer.

In the tobacco rotation, phosphorus has been the outstanding requirement. Potash and nitrate of soda in addition to acid phosphate have produced good increases in tobacco. However, if tobacco had not been grown on a clover sod the increase due to the use of nitrogen would without doubt have been greater. If manure had been used the increase due to nitrogen and potash would without doubt have been smaller.

For suggestions for fertilizing tobacco, see page 349.

THE GREENVILLE SOIL EXPERIMENT FIELD

The soil of this field is typical of the Western Coal Field and the results may safely be applied to the soils of this area and also to the sandstone area bordering on the Western Coal Field.

Work was begun on this field in 1913, but on account of modification in the plans of the field having been made in 1915, the first three years are left out of the averages as shown in the table of results, in order that all treatments may be put on a comparable basis. Leaving off the first three years does not materially affect the average except in the case of tobacco, which will be specially discussed.

Two rotations are used on this field. One consists of corn, soybeans, wheat and clover, with a rye cover crop between the corn and soybeans. Limestone and fertilizers have been used in this rotation as follows: Where limestone has been used it

has been applied at the rate of two tons per acre once in a rotation period for two rounds of the rotation, after which its use was discontinued. Acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at the rate of 1,600 pounds per acre for a rotation for two rounds of the rotation after which these materials were used in half these quantities. Muriate of potash or its equivalent has been used at the rate of 200 pounds per acre for a rotation.

Limestone and fertilizers have been applied when the ground was prepared for corn. The rock phosphate is plowed under and all other materials are disked in on the broken ground. The fertilizer applications are being shifted to the wheat land but this change does not affect the results reported in this bulletin.

Manure was used on the corn ground on all plots except No. 1, at the rate of six tons per acre for one round of the rotation, from 1916 to 1919. After this it was planned to use manure regularly and return it to each plot, except No. 1, at a rate equal to the weight of the crops removed, but it was impossible to obtain a regular supply of manure. The cornstalks and wheat straw were returned and the second crop of clover was turned under from 1920 to 1924, but this is not sufficient to maintain a nitrogen supply (See discussion on page 344). The use of manure was begun again with the corn crop of 1925.

The soil treatments used and the average crop yields obtained in this rotation are shown in table 19.

TABLE 19.—Average Crop Yields Per Acre in the Four-Year Rotation, Greenville Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus. Ave. 10 Crops	Soybean Hay, Lbs. Ave. 10 Crops	Wheat, Bus.† Ave. 9 Crops	Clover† Hay, Lbs. Ave. 9 Crops	Crop Increases**				
						Treatment Producing the Increase	Corn	Soybean Hay	Wheat	Clover Hay
1	O	18.2	1282	2.0	340	....	.....	.....	.....	.....
2	ML	30.2	2484	6.4	1477	L	2.3	649	1.5	585
3	M	27.9	1835	4.9	892	M	9.7	553	2.9	552
4	MAP	34.9	2851	9.5	1866	AP	7.8	1019	4.6	1040
5	MRP	35.7	3090	11.8	2146	RP	9.4	1261	6.9	1388
6	MAPK	34.0	2853	11.0	1671	APK	8.5	1027	6.1	980
7	MLAP	40.4	3669	15.7	2564	LAP	15.6	1845	10.9	1942
8	MLRP	36.3	3259	11.9	1906	LRP	12.3	1438	7.1	1442
9	MAPK	28.4	2261	9.4	1362	APK	5.2	443	4.6	876
10	M	22.4	1815	4.8	420	....	.....	.....	.....	.....
11	MLAPK	40.5	3519	14.8	2952	LAPK	18.1	1704	10.0	2532
12	MRPK	40.5	3292	13.6	2757	RPK	18.1	1477	8.8	2337
13	MLRPK	42.7	3423	13.0	2687	LRPK	20.3	1608	8.2	2267

* O = No treatment; M = manure and crop residues; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash.

**Manure and crop residues having been used on all plots except No. 1. The increases due to limestone and the various fertilizers are the increases made by these treatments in addition to increases made by manure and residues applied.

The increases in yields have been computed between plots 3 and 10 by assuming a uniform variation in soil between those plots. It would perhaps be as satisfactory to determine the increase by subtracting the yield of the nearest check plot (3 or 10).

†There was no wheat crop in 1920 on account of weather preventing sowing in the fall of 1919. Clover was a failure in 1925 due to drouth and winter killing. These years are not included in the averages.

The other rotation on this field consists of tobacco, wheat and clover. For two years at the beginning potatoes occupied the place of wheat.

Where limestone has been used in this rotation it has been applied at the rate of two tons per acre, once in a rotation, for two rounds of the rotation, after which its use was discontinued.

Acid phosphate was used at the rate of 600 pounds per acre for a rotation, for two rounds of the rotation, after which it was reduced to 300 pounds per acre. Sulfate of potash or its equivalent has been used at the rate of 150 pounds per acre for a rotation.

Nitrate of soda has been used at the rate of 100 pounds per acre on tobacco and 100 pounds per acre on wheat except that on plot 8 it has been used at the rate of 200 pounds per acre on tobacco from the bgeinning and was used at the rate of 200 pounds per acre on all nitrate plots on tobacco in 1923-25.

No manure has been used in this rotation. The second crop of clover has been plowed under, the wheat straw has been returned to the clover sod and plowed under and the tobacco stalks have been spread on the wheat.

The treatment used and the average crop yields obtained in this rotation are shown in Table 20.

TABLE 20.—Average Crop Yields Per Acre in the Three-Year Rotation, Greenville Soil Experiment Field.

Serial Plot No.	Treatment*	Tobacco, Lbs.				Wheat, Bus.†		Clover Hay, Lbs.	
		Ave. 12 Crops	Increase	Ave. 10 Crops	Increase	Ave. 8 Crops	Increase	Ave. 9 Crops	Increase
1	LAP	875	509	840	482	20.2	13.0	3281	2543
2	LAPK	.....	.....	893	535	20.1	12.9	3647	2909
3	LAPN	849	483	771	413	21.9	14.7	3418	2680
4	APN	.....	.....	783	425	17.7	10.5	2256	1588
5	O	366	.....	358	.....	7.2	.....	738	.....
6	LAPKN	956	590	904	546	20.2	13.0	3161	2423
7	APKN	992	626	919	561	19.8	12.6	2642	1904
8	LAPKN (2N)	918	552	857	499	17.6	10.4	2794	2056

* O = No treatment; L = limestone; AP = acid phosphate; K = potash; N = nitrate of soda.

†Wheat for 1924 was winter-killed. Not included in averages.

The results from this field clearly show the great value of limestone and phosphate fertilizers in improving these soils. The results do not justify the use of limestone without a phosphate fertilizer. The results show conclusively that when lime is used, acid phosphate is much more effective than rock phosphate, but that on unlimed soil rock phosphate is more effective than acid phosphate at the rates at which the two forms were used.

The results do not justify the recommendation of potash on any crop except tobacco.* On account of the high acre value of tobacco the increases due to potash are profitable. The results on tobacco indicate that nitrogen and potash both should be used in the fertilizer in order to get the best results.

The yields of tobacco in these experiments have not been as large as would be expected from the amount of fertilizers used on the best plots although the increases due to fertilizers have been large. The best plot (No. 7) has given an average yield of 992 pounds per acre, against 366 pounds on the check plot. A number of unfavorable seasons and diseases have kept down the yield. A three-year rotation is too short for tobacco, for when tobacco is grown so frequently as this the soil becomes infected with a disease known as root-rot. The longer the rotation the less the injurious effect of this disease. The leaf spot diseases, for which no satisfactory control has yet been found, have helped to keep down the yield. It is hoped that experimental work now under way will soon develop means of controlling both classes of diseases.

For more specific suggestions for the fertilization of dark tobacco, see page 349.

THE RUSSELLVILLE SOIL EXPERIMENT FIELD

This field was established in 1913 and was discontinued at the end of 1924. The soil is classified as Decatur Silt Loam and is typical of a large part of the southwestern limestone area sometimes called the St. Louis limestone area and sometimes the Mammoth Cave limestone area. The results are applicable to the entire limestone area of Southwestern Kentucky.

Three rotations have been used on this field. One consists of corn, soybeans, wheat and clover with a rye cover crop between corn and soybeans. Limestone and fertilizers have been used in this rotation as follows: Where limestone has been used it has been applied at the rate of two tons per acre once in a rotation period for two rounds of the rotation, after

*See Bulletin No. 228, page 109, for a discussion of variations in the soil on this field which account for the higher yields on plots 12 and 13 than are found on plots 5 and 8 in the 4-year rotation (Table 19).

which its use was discontinued. Acid phosphate was used at the rate of 800 pounds per acre and rock phospate at the rate of 1,600 pounds per acre for a rotation period, for two rounds of the rotation, after which these materials were used in half of these quantities. Muriate of potash or its equivalent has been used at the rate of 200 pounds per acre per rotation, except for the one application of 400 pounds per acre in the first round of the rotation. Where nitrate of soda was used, 100 pounds per acre was used on corn and 100 pounds per acre as a top dressing on wheat.

Limestone and the fertilizers (except nitrate of soda) have been applied when the ground was prepared for corn. The rock phosphate is plowed under and the other materials are disked in on the broken ground.

Manure was used on all plots on the corn ground except plot No. 1 at the rate of 6 tons per acre for one round of the rotation from 1916 to 1919. After this manure was used on the corn plots, except 1 and 11, at a rate equal to the weight of crops removed from the four corresponding plots in the previous rotation. The second crop of clover is left on the ground.

The corn crop of 1913 was a failure on account of drouth and the impoverished condition of the soil. The wheat crop of 1923 was not threshed on account of severe damage in the shock from rain and weevil before it could be threshed. The clover crop of 1922 was a failure on account of drouth in 1921. These years are not included in the averages.

The soil treatments used and the average crop yields obtained are shown on table 21.

TABLE 21.—Average Crop Yields Per Acre. Russellville Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus. Ave. 11 Crops	Soybean Hay, Lbs. Ave. 11 Crops	Wheat, Bus. Ave. 9 Crops	Clover Hay, Lbs. Ave. 9 Crops	Crop Increases**				
						Treatment Producing the Increase	Corn	Soybean Hay	Wheat	Clover
1	O	28.9	1704	8.4	1354	....	.....	.....	.....	.....
2	ML	38.7	2660	10.2	2816	L	8.7	657	0.2	1190
3	MAP	37.1	2431	13.2	2381	AP	7.1	428	3.2	755
4	M	30.0	2003	10.0	1626	M	1.1	299	1.6	272
5	MAPK	34.0	2352	13.8	2303	APK	4.0	349	3.8	677
6	MRP	35.8	2518	15.5	2657	RP	5.8	515	5.5	1031
7	MLAP	46.3	2770	18.3	3523	LAP	14.9	758	7.8	2026
8	MLRP	45.2	2753	16.0	3420	LRP	12.5	733	4.9	2051
9	MLRP ½	44.1	2598	14.8	3059	LRP ½	11.4	578	3.7	1690
10	M	32.7	2020	11.1	1369	....	.....	.....	.....	.....
11	L†	41.3	2693	13.9	2884	L	8.6	673	2.8	1515
12	MLAPK	46.1	2894	19.1	3407	LAPK	12.2	773	7.0	2194
13	M	33.9	2121	12.1	1313	....	.....	.....	.....	.....
14	MLRPK	45.1	2755	15.0	3137	LRPK	11.2	634	2.9	1824
15	MLRPKN	47.6	2775	17.3	3259	LRPKN	13.7	654	5.2	1946
16	MRPK	37.1	2534	14.7	2591	RPK	3.2	413	2.6	1278

*O = No treatment; M = manure; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; N = nitrate of soda.

**Manure having been used on all plots except No. 1, the increases due to limestone and the various fertilizers are in addition to the increases produced by manure.

Crop increases are calculated by subtracting the yields of the nearest check plot from the yields of the treated plots.

†This plot (11) in each of the four series received one application of potash, in the beginning of the work. Manure was used for one round of the rotation after which its use was discontinued, in order to compare lime alone with manure and lime on plot 2.

Tobacco Rotations: Two tobacco rotations were run on this field. One was clover, tobacco, corn and wheat and the other was clover, corn, tobacco and wheat. A rye cover crop was used between the corn and tobacco.

The soil in both rotations received a basic treatment of two tons of limestone and 800 pounds of acid phosphate per acre when the clover sod was broken. No further application of these materials was made during the four years. A uniform application of 6 tons of manure per acre was made at the same time except for the first crop of tobacco in the second rotation.

On this basic treatment potash and nitrate of soda applications were made as indicated in table 22, which gives the results obtained.

On account of the difficulty of getting labor at the right time only five crops of tobacco were obtained during the period this field was operated.

TABLE 22.—Average Yields of Tobacco in Different Rotations and with Different Fertilizer Treatments. Russellville Soil Experiment Field.

Plot No.	Treatment in Addition to Basic Treatment	Tobacco After Clover		Tobacco After Corn	
		Pounds Per Acre	Increase	Pounds Per Acre	Increase
1	No additional treatment	844		934	
2	100 lbs. sulfate of potash per acre	879	15	983	49
3	100 lbs. nitrate of soda per acre	948	104	1051	117
4	100 lbs. sulfate of potash } 100 lbs. nitrate of soda } per acre	889	45	1038	104

On four out of the five tobacco crops ammonium sulfate and dried blood were compared with nitrate of soda, the three materials being used in amounts carrying the same amount of nitrogen, with 100 pounds of nitrate of soda as the basis of comparison. Potash was used with each material. As an average of the two rotations for four years each, making 8 tests of each material, the yields were as follows:

Fertilizer containing nitrate of soda..... 964 lbs. per acre
Fertilizer containing sulfate of ammonia.. 996 lbs. per acre
Fertilizer containing dried blood..... 962 lbs. per acre

The effect of the rotations on the yields of the other crops in the rotation is interesting since there is no difference in the soil treatment in the two rotations.

	Tobacco Lbs.	Corn Bus.	Wheat Bus.	Clover Lbs.
Rotation 1.				
Clover, tobacco, corn, wheat....	890	39	16	2735
Rotation 2.				
Clover, corn, tobacco, wheat....	1000	52	21	3525

In the case of corn the large difference was due mainly to one crop of corn in an extra good season. Leaving this crop out the difference is reduced to 4 bushels. Rotation No. 2 is decidedly the better.

The treatment nedeed on soils of this type is clearly indicated by the results of these experiments. It is the use of limestone, phosphate and the return of manure.

An interesting result is the small increase in crops produced by the use of only the amount of manure that can be produced from crops grown upon soil which has not been treated with limestone or phosphate (plot 4). The use of lime without phosphate has produced fair increases in all crops in the corn, soybean, wheat, and clover rotation except wheat, while the use of phosphate alone has produced fair increases in all crops. Rock phosphate has been more effective on unlimed ground than acid phosphate, while the reverse is true on limed ground.

The use of nitrogen in the fertilizer has increased the yield of tobacco enough to be profitable under the conditions of this experiment. If manure had not been used on the tobacco land, nitrogen would doubtless have increased the yield more.

THE LONE OAK EXPERIMENT FIELD

The Lone Oak Soil Experiment Field is located in McCracken County about four miles southwest of Paducah. Work was begun here in 1913, although the rotation was not fully established until 1915. The rotation was temporarily suspended at the end of 1923 in order to try methods of eliminating wild onions with which the field was badly infested and which the rotation and cultivation methods used did not eradicate. However, corn yields were obtained by plots in 1924 and 1925.

The rotation used was corn, soybeans, wheat and clover. Limestone and fertilizers were used as follows: Where limestone has been used it has been applied at the rate of two tons per acre once in a rotation period for two rounds of the rotation, after which its use was discontinued. Acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at

the rate of 1,600 pounds per acre for a rotation period, for two rounds of the rotation, after which these materials were used in half of these quantities. Muriate of potash or its equivalent has been used at the rate of 200 pounds per acre per rotation, except for the one application of 400 pounds per acre in the first round of the rotation. Where nitrate of soda was used 100 pounds per acre was used on corn and 100 pounds per acre as a top dressing on wheat.

Limestone and the fertilizers (except nitrate of soda) have been applied when the ground was prepared for corn. The rock phosphate is plowed under and the other materials are disked in on the broken ground.

Manure was used on all plots of the corn ground, except No. 1 and No. 11, at the rate of 6 tons per acre for one round of the rotation, from 1916 to 1919. After this time the cornstalks and wheat straw were returned on all plots except No. 1 and No. 11. From 1916 to 1919 the cornstalks and wheat straw were returned to plot No. 11. The second crop of clover was left on the ground.

The soybean crop of 1915 was harvested for seed. The soybean hay crop of 1920 was lost because of continued rains. Clover was a failure in 1923 on account of drouth in 1922. The crop yields on this field and the treatments used are given in table 23.

TABLE 23.—Average Crop Yields Per Acre. Lone Oak Soil Experiment Field.

Serial Plot No.	Treatment*	Corn Ave. 13 Crops	Soybean Hay, Lbs. Ave. 9 Crops	Wheat, Bus. Ave. 10 Crops	Clover Hay, Lbs. Ave. 7 Crops	Crop Increases**				
						Treatment Producing the Increase	Corn	Soybean Hay	Wheat	Clover
1	O	28.4	2011	7.6	903	....	.....	.....	.....	.....
2	ML	36.2	2591	10.8	2091	L	5.2	327	0.7	884
3	M	31.0	2264	10.1	1207	M	2.6	253	2.5	304
4	MAP	33.3	2504	11.6	1563	AP	.8	104	1.4	177
5	MAPK	35.9	2761	11.7	2151	APK	2.0	225	1.5	586
6	MRP	35.4	2735	12.5	2303	RP	.1	63	2.2	559
7-8	M	36.8	2809	10.3	1924	....	.....	.....	.....	.....
9	MLAP	41.3	3503	18.2	3584	LAP	4.9	798	7.4	1656
10	MLRP	43.8	3507	17.9	3389	LRP	7.9	707	6.6	1457
11	LAP	42.1	3473	19.5	3913	LAP	6.6	678	7.7	1977
12	M	35.1	2790	12.2	1939	....	.....	.....	.....	.....
13	MK	36.2	2792	12.7	1954	K	1.6	48	.4	22
14	MLK	38.7	3192	15.8	2944	LK	4.5	439	3.5	1020
15	MLAPK	40.6	3442	19.5	3727	LAPK	6.9	788	7.1	1810
16	M	33.2	2609	12.4	1909	....	.....	.....	.....	.....
17	MLRPK	43.1	3292	16.2	3364	LRPK	9.9	683	3.8	1455
18	MLAPKN	40.9	3408	19.7	3664	LAPKN	7.7	799	7.3	1755

* O = No treatment; M = manure and crop residues; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; N = nitrate of soda.

**The crop increases attributed to limestone and the various fertilizers are the increases above any increase produced by the manure and crop residues used. Increases are calculated by assuming a uniform variation of soil between check plots.

A discussion of these results will be found in connection with the Mayfield results (page 339) which are similar to these.

THE MAYFIELD SOIL EXPERIMENT FIELD

Work was begun on this field in 1913. A four-year rotation of corn, soybeans, wheat and clover is used on part of this field. (Winter oats occupied the place of soybeans for the first three years.)

Fertilizer and limestone have been used in this rotation as follows: Where limestone has been used it has been applied at the rate of two tons per acre once in a rotation period, for two rounds of the rotation, after which its use was discontinued.

Acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at the rate of 1,600 pounds per acre for a rotation period, for two rounds of the rotation, after which these materials were used in half of these quantities. Muriate of potash or its equivalent has been used at the rate of 200 pounds per acre per rotation, except for the one application of 400 pounds per acre in the first round of the rotation. Where nitrate of soda was used 100 pounds per acre was used on corn and 100 pounds per acre as a top dressing on wheat.

Limestone and the fertilizers (except nitrate of soda) have been applied when the ground was prepared for corn. The rock phosphate is plowed under and the other materials are disked in on the broken ground. The fertilizer applications are being shifted to the wheat land but this change does not affect the results reported in this bulletin.

Manure was used on all plots on the corn ground except plots No. 1 and No. 10 at the rate of 6 tons per acre for one round of the rotation, from 1916 to 1919. After this, manure was used on the corn plots except 1 and 10 at a rate equal to the weight of the crops removed from the four corresponding plots in the previous rotation. The second crop of clover is left on the ground. From 1916 to 1919 plot 10 had the cornstalks and wheat straw returned to it. Since then no manure or residues have been returned.

The corn crop of 1919 was destroyed for experimental purposes by cattle breaking into the field. Soybeans were not introduced into the rotation until 1916, winter oats occupying their place previous to this time. There was no wheat crop in 1920 on account of a wet season preventing the sowing of wheat. The clover crop of 1923 was a failure on account of drouth in 1922.

The crop yields obtained on this field and the treatments used are given in Table 24.

TABLE 24.—Average Crop Yields Per Acre, Four-Year Rotation, Mayfield Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus. Ave. 12 Crops	Soybean Hay, Lbs. Ave. 10 Crops	Wheat, Bus. Ave. 11 Crops	Clover Hay, Lbs. Ave. 9 Crops	Crop Increases**				
						Treatment	Corn	Soybean Hay	Wheat	Clover Hay
1	O	23.7	1822	4.6	381	O	.....	.....	.....	.....
2	ML	36.9	3051	10.4	2314	L	8.2	837	4.1	1767
3	M	28.7	2214	6.3	547	....	5.0	392	1.7	166
4	MAP	30.3	2573	8.9	767	AP	.7	299	2.2	177
5	MRP	34.2	2868	9.7	1625	RP	3.8	535	2.7	632
6	MLAP	44.4	3608	16.5	3349	LAP	13.1	1215	9.2	2674
7	M	32.2	2452	7.7	717	....	.....	.....	.....	.....
8	MLRP	44.5	3619	17.3	3201	LRP	12.2	1108	9.6	2409
9	MLAP	40.4	3598	18.0	3393	LAP	8.0	1028	10.2	2526
10	LAP	36.8	3496	15.1	3148	LAP	4.2	867	7.3	2207
11	M	32.7	2688	7.8	1016	....	.....	.....	.....	.....
12	MK	33.5	2780	9.5	978	K	0.0	44	1.6	—132
13	MLK	44.2	3889	15.8	3053	LK	10.0	1105	7.8	1849
14	MLAPK	47.6	4149	20.5	4129	LAPK	12.6	1316	12.5	2831
15	M	35.7	2881	8.1	1392	....	.....	.....	.....	.....
16	MLRPK	45.3	3950	13.7	3701	LRPK	9.6	1069	5.6	2309
17	MLAPKN	42.7	3918	18.8	3839	LAPKN	7.0	1037	10.7	2447

* O = No treatment; M = manure; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; N = nitrate of soda.

**The crop increases attributed to limestone and the various fertilizers are the increases above any increase produced by the manure used. Increases are calculated by assuming a uniform variation of soil between check plots.

TOBACCO ROTATIONS

Several tobacco rotations are conducted on this field. Where limestone has been used it has been applied at the rate of two tons per acre when the ground was prepared for tobacco. This was done for two rounds of the rotation, after which its use was discontinued. Acid phosphate was used at the rate of 600 pounds per acre per rotation and sulfate of potash at the rate of 150 pounds per acre per rotation, both materials being applied in the full amount on the tobacco ground. After two rounds of the rotation acid phosphate was reduced to 300 lbs per acre. Nitrate of soda was used at the rate of 100 pounds per acre each

on tobacco and wheat except that in 1924 and 1925 it was used at the rate of 200 pounds per acre on tobacco.

The crop yields obtained in these rotations and the treatments used are given in Table 25.

TABLE 25.—Average Crop Yields in the Tobacco Rotations. Mayfield Soil Experiment Field.

Serial Plot No.	Treatment*	Tobacco, Lbs. Ave. 9 Crops	Wheat, Bus. Ave. 11 Crops	Wheat, Bus. Ave. 5 Crops	Hay, Lbs. Ave. 9 Crops	Hay, Lbs. Ave. 6 Crops	Crop Increases		
							Tobacco 9 Crops	Wheat Last 5 Crops	Hay, 9 Crops
1	AP	820	14.2	12.6	1602	.....	196	8.8	616
2	LAP	942	22.7	22.2	3738	.....	318	18.4	2752
3	O	624	6.6	3.8	986	.....	.....	.....	.....
4	LAPK	926	18.5	17.5	3330	.....	302	13.7	2344
5	LAPKN	1070	22.1	21.2	4078	.....	446	17.4	3092
6	LAPN	997	.....	22.2	4071	.....	373	18.4	3085
7	AP	798	.....	15.2	.....	2252	174	11.4	.....
8	LAP	942	.....	22.8	4555	4264	318	19.0	.....
9	AP	1028	.....	16.3	2322	2327	404	12.5	.....

* AP = Acid phosphate; L = limestone; K = potash; N = nitrate of soda.

The rotation on plots 1 and 6 is tobacco, wheat, clover.

The rotation on plot 7 is tobacco, wheat, mixture of orchard grass and Japan clover. The rotation on plot 8 is tobacco, wheat, sweet clover. The rotation on plot 9 is tobacco, wheat and Japan clover. On plot 6 winter oats was used for a while instead of wheat. On plots 7, 8 and 9 rye was used instead of wheat until the last five years, the rye being clipped when jointed and left on the ground to represent pasturing. On plot 7 orchard grass only was cut for a while. It has never made a satisfactory growth, so it is not cut now, but Japan clover is cut in the fall. This has been done for the last 6 years.

Japan clover is seeded on the wheat on frozen ground in March, and reseeds itself in the fall, usually giving a very heavy stand the next year when it is cut for hay. One year it failed to reseed sufficiently to make a crop and one year it was too short

to cut on account of drouth. An average of the actual crops on plot 9 was 2,613 pounds per acre. The highest yield was 5,690 pounds per acre and the lowest, 1,256 pounds.

It is significant that the yield of tobacco in the Japan clover rotation is only 42 pounds less than in the best fertilizer treatment in the tobacco-wheat-red clover rotation. Where lime cannot be used a great deal of improvement can be made by using a phosphate fertilizer and growing Japan clover in the rotation. If Japan clover were fertilized with a phosphate, it would make a good hay crop on many soils where it does not get high enough to cut when not fertilized.

The soils of the Lone Oak and Mayfield fields are very similar and the results on the two soil experiment fields are quite similar. The outstanding requirements for improving these soils are the use of lime and phosphate, the use of legumes in the rotation, and the return of manure or the plowing under of the legumes.

The returns from phosphate without limestone have been very poor on both fields. The returns from limestone alone have been poor on the Lone Oak field, but better than from phosphate alone. The returns from limestone alone have been fair at Mayfield. The returns from limestone and phosphate used together have been profitable on both fields but much better at Mayfield, due in a large measure, no doubt, to the larger use of manure in the four-year rotation on this field. Worn soils cannot be brought to a high state of productiveness without either turning under legume crops or returning manure made from feeding legumes along with other crops.

Rock phosphate has been more effective on unlimed soil than acid phosphate, while on limed soil it has been about as effective as acid phosphate.

Tobacco has been increased more than enough (128 pounds per acre) by the use of nitrogen and potash to pay for their use at fair prices for tobacco. No manure was used in the tobacco rotation and no legumes were turned under except what growth the clovers made the year they were seeded and the second growth after harvesting.

The results of the Lone Oak and Mayfield experiment fields are applicable to the region west of the Tennessee River with the exception of the fertile bottoms of the Ohio and Mississippi Rivers.

For suggestions for fertilizing tobacco, see page 349.

FERTILIZER TESTS AND VARIETY TESTS ON COTTON

On the Mayfield experiment field there are five series of plots, similarly treated. On these is run a four-year rotation of corn, soybeans, wheat and clover. The first and fifth series were planted to the same crop each year.

In 1924 one of these duplicate series was withdrawn from the rotation and used for fertilizer tests on cotton. This series had had three rounds of the rotation, named above, and had therefore had two applications of limestone on the limed plots and three applications of fertilizers on the variously fertilized plots, according to the rates and manner of application named on page 335. All plots except No. 1 and No. 10 had had applications of manure in 1917 and 1921. This series was in clover that would have been harvested in 1924, but the spring growth was turned under in preparation for cotton April 15, when there was a good growth of clover on plots that had lime and phosphate on them.

No additional lime was applied for the cotton in 1924. The various fertilizers were used as follows:

Acid phosphate	200 lbs. per acre
Rock phosphate	400 lbs. per acre
Muriate of potash	100 lbs. per acre
Nitrate of soda	100 lbs. per acre (plot 17)

All fertilizers were applied broadcast except nitrate of soda, which was applied along the sides of the rows after the cotton was thinned.

In 1925 the series of plots, which were tenth acres, was divided into two series of twentieth acre plots to be used in a rotation of cotton and cowpeas, with a rye cover crop each winter.

In 1925 no additional fertilizers were used except nitrate of soda on plots 9 and 17 at the rate of 200 lbs. per acre along the sides of the row after the cotton was thinned.

The yields of cotton are given in Table 26.

TABLE 26.—Yields of Cotton in Fertilizer Tests. Mayfield Soil Experiment Field.

Serial Plot No.	Treatment*	Yield Per Acre of Seed Cotton			
		1924 Lbs.	1925 Lbs.	Ave. Lbs.	Increase Lbs.
1	O	205	148	177	.....
2	ML	480	232	356	10
3	M	470	222	346	74
4	MAP	480	528	504	165
5	MRP	555	696	626	293
6	MLAP	430	549	490	164
7	M	480	158	319	.....
8	MLRP	650	306	478	126
9	MLAP†	725	390	558	173
10	LAP	740	633	687	270
11	M	605	295	450	.....
12	MK	740	232	486	9
13	MLK	1130	380	755	251
14	MLAPK	1485	760	1123	594
15	M	795	317	556	.....
16	MLRPK	1320	506	913	357
17	MLAPKN	1485	549	1017	461

* O = No treatment; M = manure; L = limestone; AP = acid phosphate; K = potash; N = nitrate of soda.

†Plot No. 9 had 200 lbs. of nitrate of soda per acre in 1925, but none in 1924.

In 1924 the season was very favorable for cotton. A good stand was obtained, the plants made excellent growth and fruited well thruout the summer. The crop opened and was saved with good weather. The reverse condition was true in 1925. The cotton came up poorly because of a drouth following planting and tho a stand finally came thru, the later plants never matured properly. On plots 4 and 5 which are on lower ground where moisture conditions were more favorable, a very good stand of cotton was secured immediately and for that reason

the cotton matured and opened earlier than elsewhere. The long drouth during the latter part of the summer prevented full development and also caused the crop to open up before reaching maturity. Rains setting in just after the first picking was made prevented the other pickings from being made; therefore the results for 1925 are not complete.

Variety tests were conducted on a rather thin piece of land on this field in 1924 and in 1925. These tests were fertilized as follows:

In 1924.	Acid phosphate	200 lbs. per acre
	Sulfate of potash	50 lbs. per acre
	Nitrate of soda	100 lbs. per acre
In 1925.	Acid phosphate	350 lbs. per acre
	Sulfate of potash	50 lbs. per acre
	Nitrate of soda	200 lbs. per acre

These fertilizers were drilled in the row before planting with the exception of one-half of the nitrate of soda which was applied along the row after cotton had been thinned.

THE VARIETIES AND YIELDS ARE AS FOLLOWS:

Variety	1924			Variety	1925		
	Yield Per A. Seed Cotton Pounds	Per Cent at First Picking	Per Cent Lint Cotton		Yield Per A. Seed Cotton Pounds	Per Cent at First Picking	Per Cent Lint Cotton
Tenn. Trice	781	57.6	40.0	Tenn. Trice	858	57.4	33.3
Miss. Trice	719	42.9	29.6	King	551	17.9	37.3
Express	719	36.7	28.7	Express	737	52.8	32.3
Delfos "6102"	669	33.9	29.9	Delfos "6102"	684	51.7	33.9
Cleveland	656	34.2	30.5	Cleveland	731	41.3	34.9
Acala	488	19.9	36.0	Acala	705	45.7	33.3

Cotton varieties suitable for Kentucky's comparatively short growing season should combine the quality of earliness with the capacity for making good yields. Above are shown the comparative yields of seed cotton; earliness, as indicated by the per cent of the total obtained at the first picking, and the per cent of lint ginned out.

In 1925 a fertilizer test of cotton was conducted on a series of plots at Lone Oak that had been handled in exactly the same way as the soils at Mayfield up to the fall of 1924, except that this series had had only one application of manure but had the corn stalks and wheat straw returned in 1921. In the fall of 1923 this series, then in young clover, was plowed up and was seeded to soybeans in 1924, followed by a cover crop of wheat. In 1925 the series was broken and the various fertilizers were applied as follows:

Acid phosphate	400 lbs. per acre
Rock phosphate	800 lbs. per acre
Muriate of potash	200 lbs. per acre
Nitrate of soda	200 lbs. per acre

All fertilizers were applied broadcast except nitrate of soda which was applied along the cotton rows after thinning.

The yields of cotton are given in Table 27.

TABLE 27.—Yields of Cotton in Fertilizer Tests. Lone Oak Soil Experiment Field.

Serial Plot No.	Treatment*	Yields Per Acre, Seed Cotton, Lbs.	Increase†	Per Cent Secured at First Picking
1	O	450	115	48.9
2	LM	485	150	51.6
3	M	335	.....	43.0
4	APM	705	336	68.1
5	APKM	765	362	62.8
6	RPM	635	199	71.7
7	M	470	.....	64.9
8	M	435	.....	57.5
9	LAPNM	565	143	67.3
10	LRPM	490	79	61.2
11	LAP	500	102	68.0
12	M	385	.....	52.0
13	KM	400	5	50.0
14	LKM	410	15	53.7
15	LAPKM	625	180	71.2
16	M	465	.....	59.1
17	LRPK	575	110	59.1
18	LAPKN	680	215	63.1

*O = No treatment; M = manure and crop residues; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; N = nitrate of soda.

†The crop increase attributed to limestone and the various fertilizers are the increases above any increase produced by the manure and crop residues used. The increases are calculated by assuming a uniform variation of soil between check plots.

The year 1925 was very unfavorable for cotton as was explained in connection with the experiments at Mayfield. The same difficulty was experienced in getting a stand as at Mayfield; however, the cotton opened fairly well and both pickings were saved. The per cent of seed cotton obtained at the first picking is shown for each treatment as this is indicative of earliness. The Tennessee Trice variety was used in the experiment. The average turn-out of lint from the seed cotton was over 35%.

THE HOPKINSVILLE SOIL EXPERIMENT FIELD

A soil experiment field was established in Christian County on the limestone area in 1922, the chief object of which was to investigate the causes of the low yields of wheat in Christian County and similar areas. Since this work has been in progress such a short time, a report is not included in this bulletin. It may be stated that the results so far are very similar to those of the Russellville Experiment Field which was upon the same general type of soil. A mimeographed report has been issued which anyone interested may obtain upon request addressed to the Experiment Station, Lexington.

THE USE OF LEGUMES AND MANURE

While lime and fertilizers are necessary to the growing of clovers and greatly increase the growth of cowpeas and soybeans, and other crops to some extent, soils cannot be brought to a high state of productivity without either turning under the legume crops or returning the manure made by feeding them and other crops grown.

The cropping system should have a legume crop on each field at least once in four years. In order that the legume may make the greatest improvement of the soil it should be turned under, grazed down, or fed with the return of manure made by feeding it along with other crops. Turning under the legume crop is an expensive way of improving the soil. Experiments have shown that manure made by feeding the crops grown in a rotation, such as is used on the experiment fields, is as effective as turning under the clover crop and returning all the stalks and straw of the other crops.

Some improvement in poor soils may be expected from growing clover and removing it and not returning manure made from it, but a high state of productivity cannot be reached. The use of soybeans and cowpeas in this way will not materially improve soils.

SUGGESTIONS FOR THE USE OF LIMESTONE AND PHOSPHATES

1. The more finely limestone is ground, the more effective it is. Limestone that will not pass a screen of ten meshes to the inch is of doubtful value. Screenings may be sold cheaply enough to justify buying them for the fine material in them. Usually the ¼-inch to dust stone will contain about 75 to 80 per cent of material that will pass a 10-mesh sieve. Limestone coarser than this is of doubtful economy at any price. Cases are known in which the coarse material ran as high as 47 per cent.

2. In nearly all parts of the state one ton of finely ground limestone per acre will be sufficient to produce clovers, including sweet clover. Two to four tons should be applied for alfalfa. On most soils two tons will be sufficient. One ton will not last as long as two tons, but it is better to have all of the farm limed with one ton per acre than half of it limed with two tons per acre. Reliming should be determined by whether clover is growing successfully.

3. Limestone may be spread either before or after plowing. If spread before plowing it should be disked in before plowing. It should also be disked in when spread on plowed ground. Limestone and acid phosphate may be spread at the same time and disked in together. Acid phosphate should not be applied before limestone. Acid phosphate and limestone may be mixed before spreading. Limestone and acid phosphate applied together should be disked in before rained upon. Generally it is not advisable to use rock phosphate on recently limed ground. Limestone may be spread at any time of the year. It should not be left on the surface if it will wash away.

4. For alfalfa it is well to apply limestone a year or two before sowing the crop. Experiments have proved that this produces better alfalfa. For clover, it is a good practice to

spread the lime on the ground for corn or some other preceding crop. The increases of the preceding crops will often pay for the limestone, and the tillage distributes the lime better for the clover.

Limestone does not often directly benefit tobacco, but it will indirectly benefit it in a rotation in which clover is grown.

5. Limestone may be spread with a shovel if care is exercised. It is necessary to get accustomed to a "swing" of the shovel that will throw the limestone evenly in a fairly broad strip. A man standing in the rear of a wagon can cover a strip about 15 feet wide at a "sling." The shovel is swung around in a semicircle on a horizontal line and so held that the limestone leaves it in a uniform stream. The "lick" must be learned by practice. The writer has seen two men spread two tons of limestone on an acre in this way in less than an hour.

6. Limestone may be spread with a manure spreader by observing the following rule: Set the spreader at the lowest number of loads it will spread per acre. Divide the amount of limestone desired per acre by the number of loads at which the spreader is set. This gives the weight of limestone to be used each load. Spread enough litter on the apron of the spreader to prevent the stone from sifting thru.

7. Time will be saved if the limestone can be spread from the wagon as hauled to the field. This can be done with the ordinary lime spreader by removing the tongue and putting in a stub tongue which can be hooked to the rear axle of the wagon so as to draw the spreader close up to the rear of the wagon box. A man shovels limestone into the spreader while another drives.

If an end-gate spreader is being used, an extra sprocket may be bought for each wagon in service and the spreader attached to each wagon as it is unloaded. The end-gate spreader has the advantage of spreading a wider strip than other types of spreaders.

8. On many soils that are only very slightly acid, such as the limestone soils of Kentucky, often a small amount of limestone will be sufficient to produce clover. The following practice is recommended for trial where limestone is difficult to obtain:

Mix 2 parts of finely ground limestone or burned lime and 1 part of acid phosphate. Drill the mixture at the rate of 1,000 pounds per acre with fall-sown grain or spring-sown oats. Seed a mixture of red and alsike clover or sweet clover on the grain in the late winter or early spring. Leave a small strip unlimed in order to check on the results.

9. *Important.* Except on the better bluegrass soils, a phosphate is just as necessary as limestone. In fact, in most cases limestone used without a phosphate will be disappointing.

10. In farm practice probably the most economical way to use acid phosphate is to drill about 400 pounds per acre when wheat or other small grain is sown. This will be sufficient for the wheat and for the clover or grass crop which usually follows wheat. If this practice is followed regularly with each rotation and manure is used on the land on which corn is grown following the clover and grass, it will not be necessary to use additional phosphate, provided the manure has been saved carefully, and as much as six to eight tons per acre has been used. Additional fertilizers will probably pay on tobacco.

11. If it is desired to use acid phosphate in connection with manure for corn, tobacco or other crops, it may be applied when the manure is being spread. When loading the spreader, place a layer of manure and sprinkle over it uniformly some acid phosphate. Two layers of manure and phosphate should give an even spread of the phosphate on the land. The amount of phosphate for each load of manure is determined by dividing the application of phosphate desired per acre by the number of loads of manure to be used per acre.

12. For inter-tilled crops, such as corn, tobacco and beans planted in rows, it is best to apply the acid phosphate broadcast, or drill it with the fertilizer attachment of a grain drill. Without doubt, it is more effective applied this way than in the row, for the feeding roots have a better opportunity to come in contact with the phosphate thruout the growing season. Broadcast applications should be made on the broken ground so that the fertilizer may be thoroly distributed in the soil in the preparation of the seed bed. Where an application of as much as 600

pounds per acre is used, to last for a period of three or four years or more, the phosphate may be applied broadcast on the unbroken ground and disked in before breaking.

Only with very small amounts of acid phosphate, say 100 pounds per acre, would drilling in the row be recommended. But we do not believe it advisable to use such small applications.

13. Experiments on some of the Kentucky experiment fields indicate that it makes very little difference in yields whether large amounts of acid phosphate are applied at once for a rotation, or the same amount is divided into annual applications for the same period of time. Very little phosphate is lost by leaching.

14. Rock phosphate should not be used in small annual applications. One thousand to 1,500 pounds per acre, sufficient for three to five years, should be applied broadcast on the unbroken ground and should be disked in before breaking. It may be applied with a lime spreader, thru the fertilizing attachment of a grain drill, or when manure is being spread, in the manner already indicated for acid phosphate.

15. Contrary to much that has been written on the subject, it has been found on the Kentucky experiment fields that rock phosphate gives good results on thin land the first year before animal manure or green manure crops have been used. Of course much larger yields will be obtained by the use of manures than without them.

16. When the price of acid phosphate is twice as much per ton as rock phosphate, or more, farmers well may consider the use of rock phosphate, altho it is more bulky and troublesome to handle. The excess of phosphorus that is stored in the soil by its use is an important consideration. After using rock phosphate two rotations at the rate above recommended, the amount may be reduced by half. Especially is this true where manure is being returned to the soil.

17. Except on soils represented by Mayfield, Lone Oak and the Berea Soil Experiment Fields, rock phosphate cannot be recommended for limed soils. On unlimed soils it has generally given results quite as satisfactory as acid phosphate and sometimes better, when used in equal money values.

SUGGESTIONS FOR THE FERTILIZATION OF TOBACCO

Suggestions for the fertilization of Burley tobacco in the central Bluegrass Region are given on pages 302-305. Outside of this region the same fertilization is recommended for both Burley and dark tobacco, as we have no experimental evidence or practical experience that would justify a difference in recommendations for the two types.

If the soil where tobacco is to be grown is in first class condition, such as a good clover sod or land manured at the rate of 10 or 12 tons per acre, it is quite likely that liberal fertilization with acid phosphate, basic slag or steamed bone meal will be sufficient. Three hundred to five hundred pounds per acre of acid phosphate or basic slag or two hundred to three hundred pounds of steamed bone meal is a liberal application.

Unless the soil for tobacco is in a high state of productivity, such as would produce something like 75 to 80 bushels of corn per acre in a favorable season, it is highly probable that it will pay to fertilize tobacco with a complete fertilizer.

The following formula is suggested for tobacco in all parts of the state outside of the better Bluegrass area:

Acid phosphate or basic slag	1150 lbs.
Nitrate of soda	675 lbs. or 500 lbs. sulfate of ammonia
Sulfate or muriate of potash	175 lbs.
	2000 lbs.

Basic slag should not be mixed with sulfate of ammonia, but should be applied separately. (If sulfate of ammonia is used, the amount of acid phosphate may be increased 175 lbs. per ton of mixture.) This is approximately a 6½-9-4 formula. Very few fertilizers offered for sale in Kentucky contain enough nitrogen for tobacco where it is really needed.

If a ready-mixed fertilizer is used it is recommended that one containing not less than 4 per cent each of nitrogen and potash be used. The percentage of nitrogen should be at least as high as the percentage of potash, and it is usually desirable that it should be higher, particularly on the thinner soils.

The fertilizer requirements of tobacco on soils of different degrees of fertility can usually be provided for as well by vary-

ing the amount of a good formula as by varying the formula. Any excess of phosphorus and potassium above the needs of the tobacco crop will be held in the soil and will be available to succeeding crops.

Since farmers are better able to judge of the productiveness of their soils in yields of corn than any other crop, the following suggestions are made for applications of fertilizers for tobacco:

If the soil will produce in a season of good rainfall,

30 to 40 bu. of corn per acre use 500 to 750 lbs. of fertilizer per acre
40 to 60 bu. of corn per acre use 300 to 500 lbs. of fertilizer per acre
60 to 80 bu. of corn per acre use 300 lbs. of fertilizer per acre

As much as 500 pounds of mixed fertilizer per acre may be used in the row if it is well mixed with the soil. A satisfactory practice is to use 200 pounds in the row and the remainder broadcast. With applications of more than 500 lbs. per acre it may as well all be applied broadcast.

It is strongly recommended that tobacco be grown only upon land kept in the best of condition thru the use of clovers and grass. Tobacco of high quality can be produced only in this way. No kind of fertilization with commercial fertilizers will take the place of a soil made fertile thru the proper use of legume and manure.

The tobacco crop can often be made to pay for the fertilizers for the succeeding crops in the rotation. An additional 300 pounds of fertilizer per acre would cost, say $7.00. An increase of 70 lbs. of tobacco per acre at 10 cents per lb. would pay for the fertilizer. But 70 lbs. of tobacco would use only a small part of the 300 lbs. of fertilizer and the excess would remain in the soil for the succeeding grain and grass crops. An application of 600 lbs. of fertilizer of the grade recommended would serve this purpose.

LIST OF PUBLICATIONS ON SOILS AND CROPS FOR FREE DISTRIBUTION

Address Director Agricultural Experiment Station, Lexington, Kentucky

Experiment Station Bulletins

191. Soil Fertility.
195. Soils of Franklin County.
228. I. Report on Soil Experiment Fields. II. Maintenance of Fertility.
232. Soybeans.

Experiment Station Circular 32—Marls for Liming Soils.

Extension Circulars

54. Ten Lessons on Soils.
56. Farm Crops.
59. Liming the Soil.
60. The Growing and Utilization of Sweet Clover in Kentucky (Revised).
70. Alfalfa.
81. Crimson Clover; Its Possibilities in Kentucky.
123. Phosphate and Limestone for Kentucky Soils.
129. Soil Erosion.
155. Production, Care and Use of Farm Manure.
161. Cotton Growing in Kentucky.
162. The Control of Angular Leaf-Spot and Wildfire in Tobacco.
163. Better Land Utilization in Kentucky.
164. The Relation of Live Stock to the Maintenance of Fertility.
174. Making Limestone More Available for Farmers.
179. Lespedeza in Kentucky.